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OF THE

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MEDICAL WAR MANUAL No. 8

Authorized by the Secretary of War
and under the Supervision of the Surgeon-General
and the Council of National Defense

Military Surgery

OF THE

Ear, Nose and Throat

BY

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MAJOR, MEDICAL RESERVE CORPS, U. S. A.

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PREFACE.

THIS manual is a review of the surgical literature of the present war in so far as it pertains to the Ear, Nose and Throat. To make it of greatest service, the subject matter of each chapter is divided into two portions: The first contains a more or less dogmatic expression of the writer's opinion, gained from his previous experience and from his study of the war literature; the second, under the heading of "Comment," offers a review of the literature in detail.

No attempt has been made to present elementary principles and practice, as it is fair to assume that commissioned otolaryngologists, for whom this manual has been especially prepared, have been trained beyond any such requirement.

Due acknowledgment is here made to the medical officers connected with the Section of Otolaryngology in the Surgeon-General's Office for their advice, interest and coöperation, which have been a source of great encouragement in the preparation of this little study of the Military Surgery of the Ear, Nose and Throat.

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CHAPTER I.

INJURIES OF THE EXTERNAL EAR.

THE wounds of the external ear may be considered under two heads:

I. Wounds of the Auricle.
II. Wounds of the External Auditory Canal.

I. WOUNDS OF THE AURICLE.

Uncomplicated wounds of the auricle are uncommon. Traumatisms involving this appendage are also, as a rule, likely to injure adjacent structures, which are far more important and receive the first consideration. On the other hand, there are doubtless many fatalities resulting from wounds of the neck and endocranial structures, in which the auricle is included. The following injuries may be sustained:

1. Complete or partial detachment or destruction.
2. Wounds of various portions, with or without laceration.
3. Perforations by bullets or shell fragments.
4. Fragments of metal or other substance embedded in the auricle.
5. Burns and scalds.

6. Contusions from direct wounds or from falling on the ground or against an object.

7. Formation of othematoma.

Treatment.—The usual plan of wound treatment is followed. Its aim should be not only to promote repair but also to prevent infection and perichondritis and to avoid post-cicatricial deformity.

1. Preliminary. The wound should be carefully cleaned and contused parts cut away with as little loss of tissue as possible. All foreign bodies should be removed at the first sitting.

2. Suture.—It is well to bring together the cut surfaces of whatever wounds may exist and to suture them with fine silk. A good cosmetic result frequently depends on this attention.

3. If the pinna be partially or even completely detached it may be reattached and preserved by careful suturing and the most rigid asepsis. The vascularity of the auricle is decided and, for this reason, the recovery even under extreme circumstances is quite possible.

4. Perichondritis.—Infection of the cartilage or of the perichondrium may result in necrosis of the cartilage with the usual accompanying deformity such as not infrequently happens in a perichondritis following mastoid operation. To avoid this, great pains must be taken to prevent infection and to combat it when it appears. It is not necessary to excise any portion of the cartilage unless it be definitely necrosed.

5. Adhesions and Stenosis.—Faulty union or inadequate or delayed attention may be followed by adhesions within the concha or between the auricle and the scalp or adhesions and stenosis at the meatus which are apt to affect either the cosmetic or auditory requirements. When the wound is in the neighborhood of the external auditory meatus, it is well to insert a gauze drain to prevent, in a measure at least, the occurrence of a stenosis.

Comment.

According to Lagarde*(1) auricle wounds are usually slit-like and heal rapidly; on the other hand, Ramsey, Grant, Whale and West(1) claim that they are apt to be lacerate with a loss of substance. They suggest that perichondritis be treated with hot fomentations and that the swellings should not be incised but punctured under aseptic precautions so as to diminish the tension. West suggests (Fraser, 2) that in making sutures they pass through the skin only and not through the perichondrium. Closier(1) states that in scalds of the concha, on account of contamination with dirt, suppuration occurs early and cicatrization is slow. Beck(3) reports a case of burn of the auricle from a hot shrapnel mass, and Alexander(3) one in which an inflammation followed an injury of the auricle which was relieved after opening of the perichondrial abscess and extraction of pieces of metal causing the infection. Thost(1, 4) reports a case of auricle wound cured by artificial sunlight. Grazing injuries may, according to Frey(1), be treated conservatively when adjacent structures are involved. Marriage's(2) plan consists in cleaning up the wound and removing the fragments of metal and applying antiseptic dressings. If the damage be very extensive it is often possible to save a greater part of the ear by performing a plastic operation. Hofer(3) says that the most important of these injuries are represented by othematoma and traumatic perichondritis, and Canuyt(3) states that Berranger Feraud reports 4 cases of complete detachment in which satisfactory union was reëstablished. Rozier(1) claims that to effectively relieve stenosis which has a tendency to reform in spite of even extensive excision of the cicatricial tissue it is necessary to enlarge the external auditory canal, cutting

*The numbers signify the order of the references listed under each author's name.

away its posterior wall up to the tympanic ring, to make an autoplastic membranous canal according to Moure's method and to exercise great care in the postoperative dressing.

II. WOUNDS OF EXTERNAL AUDITORY CANAL.

The external auditory canal may be subjected to injury in various ways, and degrees: Slight contusion, loss of substance, partial or complete detachment.

1. A projectile may penetrate directly into the canal.
2. It may traverse the canal in any direction from before backward, from behind forward, from below upward, and from above downward.
3. Foreign bodies may traumatize the canal when introduced for the purpose of evading service; insects may enter while the man is lying on the ground.
4. Burns and scalds, whether accidental or factitious.
5. The injury may be due to indirect causes or may be a part of a process involving adjacent structures.

From its position it seldom happens that the external auditory canal is injured without involvement of adjacent structures, in fact, it is usually only secondarily struck by the traumatic agent.

It lies in the pathway of projectiles passing:

1. From the parotid region backward.
2. From the mastoid region forward, inward, upward or downward.
3. From the neck upward and inward.
4. From the orbit outward and backward.
5. From the vertex downward and outward.
6. From the inferior maxillary upward and backward.

An injury of the external auditory canal may be asso*ciated with fracture* of the petrous portion, the glenoid *cavity and the mastoid* process of the temporal bone, and

of the middle fossa, all of which surround it. In addition the adjacent soft parts may be injured, especially in the parotid region.

Important structures in the neighborhood also are subject to injury:

1. The facial nerve in the aqueductus Fallopii and in the parotid portion.
2. The large vessels and nerves in the upper part of the neck.
3. The brain and its meninges.
4. The tympanic membrane and the middle ear.

Hemorrhage from the ear and pain upon movement of the temporomaxillary articulation are the two cardinal symptoms. Infection with consequent suppuration involving the middle and external ear and adjacent structures is apt to occur unless any foreign body present be removed, but stenosis is the most common result to be feared.

Prognosis.—Uncomplicated wounds of the external auditory canal result favorably so far as life and hearing are concerned; the chief danger is the formation of atresia and stenosis. Injuries of the bony canal are dangerous in so far as they are usually accompanied by involvement of adjacent structures.

Treatment.—1. If the wound is recent the fragments of metal, clothing and extraneous substances should be removed after the usual preparation. If the wound is old this will probably be impossible, as the process will then be one of suppuration or stenosis.

2. A foreign body which cannot be extracted through the meatus must be removed by making a postauricular incision and slitting the membranous canal transversely or perpendicularly. Under such circumstances great care must be exercised to prevent the formation of atresia or stenosis.

3. *If the foreign* body is embedded in the posterior canal *wall a radical* mastoid operation may be necessary.

4. The inferior maxillary should be immobilized in fractures of the external auditory canal and, if necessary, the patient should be fed with an esophageal tube or catheter introduced through the nose.

5. The canal should be dried out carefully with dry sterile cotton and boric acid powder applied, provided there is no injury of the membrana tympani or suppurative process of the middle ear present.

6. A strip of dry gauze should be inserted in the canal.

Stenosis and Atresia.—In addition to seriousness from the involvement of structures in the neighborhood, stenosis and atresia are the chief distressing results of wounds of the external auditory canal. Hearing is only slightly or temporarily affected or at least compromised in so far as the atresia, stenosis and injury of auditory apparatus are concerned.

Stenosis and atresia may be located in the meatus, cartilaginous canal or osseous canal. The method of formation is as follows:

1. The denuded surfaces, as in other narrow canals, are apt to unite and form adhesions.

2. A dense fibrous mass may form at the site of the lesion, causing a distinct partial or complete stenosis.

3. When the canal is small, the production of connective tissue may cause the formation of a membrane across the canal which may be closed entirely except for a minute opening.

4. By virtue of cicatrization a tubular stenosis is formed.

5. A circumscribed stenosis may occur at the site of a fracture from displacement of bone fragments.

6. After necrosis of the bony canal, granulations which form around the sequestrum may cause a union between the walls of the canal.

7. Simultaneous hyperplasia of the periosteum and bone formed around the bone lesions of the canal constituting hyperostosis (callous formation) will reduce the lumen of the *canal.*

There are two types of stenosis: circular stenosis, further divided into annular and valvular, and tubular.

1. Annular.—This type exists in the form of a ring which may be complete or incomplete. It is usually situated at the meatal opening or at the junction of the bony and cartilaginous portions. Sometimes the closure is so complete that it partakes of the appearance of a drum membrane.

2. Valvular.—This presents itself in various forms and usually reduces the meatal opening to a horizontal or vertical slit.

3. Tubular.—This type is composed of new formed fibrous or osseous tissue.

Treatment.—Practically nothing can be done except by a plastic operation, as the adhesions reform to a greater degree after incision. If there is no interference with healing or if there is no suppuration of the midde ear, surgical intervention is unnecessary, otherwise one of the following plans is advocated.

1. The Radical Mastoid Plastic.—The usual incision for a radical mastoid operation is made, the periosteum and soft parts being raised from the bone by an elevator. The membranous canal is carefully detached. The posterior bony canal wall is removed to the extent desired even to the annulus tympanicus and one of the forms of plastics of the membranous canal is made. In order to secure a sufficiently large meatus, the incision may be carried some distance into the concha. The usual precautions relative to the conchal cartilage are to be observed.

2. Radical Mastoid Operation.—In the presence of a mastoiditis, or of extensive destruction, the usual radical mastoid operation with plastic may be performed.

3. Moure's Plastic.—Moure uses two procedures in concluding the plastic.

(*a*) Incision perpendicular to the membranous canal, which forms a sort of horizontal T, of which the vertical incision is

barely at the entrance of the auricle. The superior and inferior flaps are everted posteriorly and if too thick or poorly approximated to the osseous surface which they are to cover, they should be cut away with a bistoury or scissors, so as to remove the portions which fall toward the interior of the canal and which approximate poorly. The flaps are sutured to the adjacent portions with catgut so far as possible so as to obtain a sufficiently large meatal opening.

(*b*) A round section is made in the concha, the center of which looks toward the interior of the meatus; in reality the external auditory meatus is enlarged at the expense of the auricle without including the skin and cartilage. In making this curvilinear incision the helix route is the safest; to prevent the tendency of the two lips of the helix thus divided from separating, the wound should be sutured with catgut at the helix. A portion of the inferior wound made in the concha should be closed and thus the meatal entrance will be reformed sufficiently to admit the end of the finger. The operation is concluded by attaching the two flaps one above and the other below.

Dressing.—After the operation, careful attention must be paid to the dressing to prevent the formation of a new cicatricial stenosis. Renewed packing with selvedged gauze should be carefully continued until healing takes place.

The postauricular wound is treated in the usual way.

Comment.

Rozier(1) calls attention to certain essential points in the anatomy of the external auditory canal, particularly with reference to the incisuræ Santorinii which are filled with fibrous tissue and which thereby give to the canal an extensibility of great service in permitting the canal to be straightened for examination and operation. If a projectile or scar tissue compromises this part of the canal, there will be considerable

interference in this regard. Ferreri(6) considers that there should be no surgical intervention in fracture of the bony canal unless it is made necessary by the presence of infection, hemorrhage, cerebrospinal otorrhea and paralysis of the facial, oculomotor or trigeminus. With this Lermoyez(1) in part agrees, but adds that when the foreign body cannot be seen with the otoscope and no otorrhea is present the operation should be postponed. If otorrhea is present, operation should be performed at once. Canuyt(3) reported a case in which a projectile penetrated through the meatus and lodged in the canal, and Cheatle (Marriage, 1) one in which a nearly spent bullet entered the meatus at a right angle and, without injuring the cartilaginous portion, reached the bony meatus, passed through the anterior wall, was deflected downward and backward, and emerged behind the upper third of the sternomastoid on the same side. Marriage(2) cites one in which a bullet entered just in front of the tragus, passed right through the external meatus and struck the tip of the mastoid process. Ruttin(5) describes 2 cases in which the membranocartilaginous portion of the canal was partially torn from the bone and another case(3) in which an epithelial cyst formed on the site of a gunshot wound of the anterior wall of the canal. Luzzati(1) mentions a case in which a bulging in the external auditory canal came from an osseous sequestrum resulting from a gunshot wound. Castellani(1) reports a similar case, and Findel(1) one in which a shell fragment, about the size of a bean, had been wedged into the canal without wounding the membrana tympani. Collet(1) reports 2 cases, of atresia relieved by radical mastoid operation with a posterior flap cut vertically like a hinge into the concha. Canuyt(3) holds that in all such cases it is necessary to know what grave lesions of the middle ear, internal ear, meninges or brain lie beyond the stenosis. A slight persisting suppuration comes very likely from the middle ear and not from the canal. He maintains that a radical mastoid operation shoul

be performed when the stenosis or atresia is complicated by an old otorrhea. On the other hand, Wolff(2) reports a case in which the suppuration was due to bone fragments from the inner side of the canal and the wall of the tympanic cavity. Fraser(2) holds that a bullet in the neighborhood may keep up a suppurative otitis, while if the foreign body be removed fatal meningitis may supervene from injury and infection occasioned by the removal. Ramsey, Grant, Whale and West(1) state that direct wounds of the bony canal, which are more or less in the axis of the meatus, will generally be immediately fatal, though it is possible for a spent bullet to lodge in the petrous. Direct wounds transverse to the meatus may shatter its walls without penetrating the cranium. Such wounds may involve the mastoid process behind and the temporomaxillary articulation in front, with extension to the pharynx, nose or upper jaw or orbit on the same side. These wounds are nearly always serious, especially when complicated by an antecedent middle-ear suppuration. When the middle ear has been disorganized or is already the seat of a chronic infection it is well to do a radical mastoid operation with plastic. By this means the whole area is drained and the temporomaxillary joint made freely accessible. Ruttin(4) found that in his cases the membranocartilaginous portion was more frequently affected than the osseous, and that atresia could always be prevented by tampons.

CHAPTER II.

INJURIES OF THE MIDDLE EAR.

ALTHOUGH lesions of the middle ear usually involve all the structures which it comprises, it is deemed best to discuss them under the following heads:

I. Tympanic membrane.
II. Tympanic cavity.
III. Mastoid process.

I. TYMPANIC MEMBRANE.

Lesions of the tympanic membrane are among the most common brought about by war conditions. They may be direct when they result from projectiles, foreign bodies or caustics, under which circumstances they are usually associated with injuries of other structures. The most frequent type, however, is that due to indirect traumatism, such as violent concussion of the head or sudden fluctuation of the air pressure in the auditory canal or Eustachian tube. For this the detonation from high explosives is the usual cause. The effect of such detonations is by no means always limited to the tympanic membrane, but is quite commonly to be found in the labyrinth. The mechanism of detonation and the relation which the tympanic membrane bears to such injuries will be discussed under Labyrinth Concussion.

Lesions.—1. Congestion and Ecchymosis.—A slight redness is found over the handle of the hammer or in Shrapnell's membrane. Sometimes there are small discrete hemorrhages in the drum membrane. Resolution may follow without incident or a perforation persists with or without suppuration

2. Perforations.—The perforations may be punctiform, linear, stellate or even fissured. They may be single or multiple. While they may occur in any part of the tympanic membrane they are to be found most commonly in the inferior half, the anterior inferior quadrant furnishing the largest member.

3. Loss of Substance.—In the severer type there is a definite loss of substance which may include the entire membrane; it may be central, peripheral or marginal.

4. Dislocation and fracture of the ossicles are infrequent.

5. Caustic and foreign-body wounds generally involve other structures or at least usually result in infection of the external or middle ear.

Symptoms.—1. Symptoms may be entirely absent; in fact, middle-ear suppuration may result without the patient being cognizant of any drum injury.

2. Hemorrhage from the ear, usually very slight and appearing at the time of the injury.

3. Deafness is usually but transitory.

4. A serous discharge sometimes moderate in quantity continues for a few days.

5. Tinnitus, if present, continues but a short time if the condition is limited to the tympanic membrane.

6. Pain is seldom present.

Course.—Unless there is a middle-ear complication the perforation cicatrizes little by little until resolution takes place. Suppurative otitis media is the common result, as the external auditory canal and the war conditions under which the patient is placed are more conducive to infection than obtains in civil life.

Treatment.—In view of the great tendency to middle-ear infection it is highly important that nothing be done to *encourage its* development; on the contrary, precaution *should be taken to avoid* it. The external auditory canal *should be carefully* cleansed out with dry cotton and dry

sterile gauze or cotton inserted into the meatus and renewed as often as necessary. All washing of the ear should be avoided unless middle-ear suppuration be present. If desired a mild iodin solution in alcohol may be applied to the membranous portion of the canal. Caustic and foreign-body wounds must be treated according to indications.

Comment.

Royet(1) describes a mild type of acute otitis which occurred in soldiers at the front which proved to be due to perforation of the membrana tympani occurring without the patients' knowledge; at least they did not find it necessary to seek medical aid until the discharge appeared. Berranger(1) reports 14 cases of drum injury, 5 from shell explosions, with minute perforations, all resulting in complete cure, 3 from torpedo explosions, 2 being mild and 1 resulting in considerable destruction, 4 from explosion of hand grenades and bombs with more serious lesions. Urbantschitsch(3) reports a case in which there was a valve-like perforation following a kick from a horse. Cheatle(1) advocates the use of iodin applied to the cartilaginous meatus. Mollison(3) describes a case in which, during an operation for suppuration following rupture of the tympanic membrane, the incus was found lying quite loose and bare and stained with powder. Hamm(1) advises thermic treatment for persistent perforation. Meyer zum Gottesberge(1) found in 105 cases in which deafness was caused by war conditions, 70 in which both drum and labyrinth were affected, 25 in which the internal ear alone, and 10 the membrana tympani alone. In 10 cases half of the drum was destroyed and in 1 case of total defect, with no history of previous trouble, the hammer was lying free in the middle ear. Saupiquet(1) divides tympanic injuries into three categories: (*a*) perforations with borders more or less torn, often with true laceration or destruction of

membrane, frequently accompanied with hemorrhage; (*b*) primarily no perforation, but an abrasion resulting in resolution with an intact drum or a necrosis with secondary perforation; (*c*) perforation with suppuration on the following day, a rapid infectious otitis media. Of 31 cases of laceration of the drum, in 1172 cases in the service of Jones-Phillipson(1), 20 occurred in the antero-inferior quadrant, 6 in the postero-inferior quadrant, 1 between the two inferior quadrants, 2 at the umbo, 1 across the two posterior quadrants and 1 in the anterosuperior quadrant. Birkett(1) finds no particular site of predilection. Fraser(2) calls attention to the occurrence of dislocation of the incudostapedial articulation following extreme concussion and Delacour(1) maintains rupture from concussion occurs only in those in whom the ear has been previously affected and in whom the tympanic membrane has lost, in part, its elasticity and resistance. The most tenacious sequelæ in order of duration are: vertigo, tinnitus and suppuration of the middle ear when it occurs. Abrand(1) concludes that the Rinné is positive, even if there is an extensive lesion, when there has been no tympanic disease; it is negative when the slightest inflammation complicates the lesion; the Weber test usually follows the Rinné, lateralization in negative Rinné and none in positive. Bourgeois and Sourdille(1) claim that when the air is projected into the canal in the direction of the projectile the rupture will be unilateral. When the increase of pressure acts on both tympanic membranes it will be bilateral. This explains why tympanic ruptures in the open air are usually unilateral, while those within enclosed walls are more often bilateral. Grant(2) reports cases in which the membrana tympani appeared to be driven in and so closely related to the ossicles that the appearance was as if the ossicles were sculptured out just as in extreme cases of relaxed membrane. The best guide to ascertain whether or not the perforation is recent or of old standing is the condition of the Eustachian tube.

If it is quite patent, it is reasonable to think that traumatic injury of the drum is recent; if the suppuration has continued for a long time and the tube is not very patent, it is impossible to say from this whether it is a chronic case or a traumatic rupture.

II. TYMPANIC CAVITY.

Direct war injuries of the tympanic cavity are usually associated with labyrinth disturbances, as the proximity of the internal ear subjects it to the influence of the traumatic agent active on the middle ear. The external auditory canal, the mastoid, the petrous bone and the cranial cavity are all likely to be involved by any projectile which strikes or lodges in the middle ear.

The pathway of the missile is practically the same as that which results in similar traumatism of the external auditory canal, except that intracranial and labyrinth injuries are more commonly associated with those of the tympanic cavity.

The tympanic membrane is practically always ruptured; in fact, it is not unusual to have the abrasion or at least congestion of the tympanic cavity in connection with the rupture.

The following comprise the injuries of the tympanic cavity:

1. Direct injuries from burns, scalds or chemicals often following attempts to evade military service.

2. Foreign bodies, such as projectiles, fragments of metal, pieces of clothing and bone, lodging in or passing through.

3. Ecchymoses, bloody extravasations, fracture of the ossicles and tympanic hemorrhages.

4. Gross lesions in association with those of adjacent structures. These include the middle fossa, the jugular bulb, the internal carotid artery, the petrous bone, the mastoid cells, the facial nerve, the abducens, the Gasserian ganglion and the lateral sinus, all of which may be more or less involved in the wound. Fracture of the floor of

cranium through the middle ear manifests itself by flow of blood or cerebrospinal fluid from the middle ear.

5. Eustachian tube injuries from gunshot wounds and penetration of foreign bodies.

Treatment.—For the milder lesions the treatment is largely negative, all washes and manipulations being interdicted. Careful dry cleansing of the canal should be undertaken and a light plug of dry sterile cotton or gauze inserted in the meatus.

Infection with resulting otitis media suppurativa is the rule, and if the lesion is not too extensive and if there are no foreign bodies present the usual routine observed in the treatment of this disease may be carried out unless there be important complications present, such as mastoid abscess, sinus thrombosis, facial paralysis, suppurative labyrinthitis, extradural or intradural abscess.

Usually an extensive injury of the middle ear, with or without a foreign body, requires the performance of a mastoid operation. If the foreign body is impacted the radical mastoid operation will be indicated. Intracranial suppuration, facial paralysis, labyrinthitis, sinus thrombosis, etc., call for the usual procedures. Unless there is serious complication or severe injury to neighboring structures the course is uninterrupted and resolution follows in a reasonable time, but much depends upon the facility with which foreign bodies can be removed and on the extensiveness of the process.

Comment.

Wicart(2) holds that where suppuration is present the middle ear succumbs more readily to detonations, and Canuyt(1 and 2) calls attention to the fact that injuries of the middle ear may aggravate old middle-ear lesions. He designates them as follows: (*a*) old otorrhea, aggravated or *recurring in those who had* no discharge on arrival at the

front; (*b*) old cured otorrhea recurring from war conditions; (*c*) old lesions, such as adhesive otitis, otosclerosis, etc. These are influenced by injuries and detonations and also by exposure and the intemperate conditions brought about by the present war. While Baldenweck(2) objects to the use of injections he favors using cotton soaked in boiled water for cleaning out the ear canal in these cases. Fractures in this region, according to Fraser(1), may run parallel to the long axis of the petrous bone or at right angle to the long axis. Longitudinal fractures, as a rule, start in the orbital region of the sella turcica and pass backward along the line of the middle-ear cleft, breaking the roof of the Eustachian tube and tympanic cavity. The fracture may then pass outward to the external meatus and squamous region. If this is the case the inner ear is not involved, although the ossicles may be dislocated and the drum-head torn. On the other hand, the fracture after reaching the roof of the tympanic cavity may pass inward through the petrous pyramid, resembling in some respects the fractures which run at a right angle to the long axis. Klestadt(1) institutes active treatment at the first signs of middle-ear infection and Alexander(1) reports that after the removal of the projectile the middle-ear suppuration rapidly subsides. Jones-Phillipson(1) found in 4 cases a firm blood clot in the middle ear bulging the membrane outward. Hofer(3) mentions as the result of indirect injuries of the tympanic cavity: fractures of the malleus handle, ecchymoses, superficial bloody extravasation and blood in the tympanic cavity. Luxations or fractures of the ossicles are exceptional. Marriage(1) quotes Hastings as reporting a case in which middle-ear hemorrhage was produced by a bomb striking the cheek, and Cheatle a similar case resulting, however, from a fall of 13,000 feet in a few minutes. Fraser(2) states that, according to West, if the patient survives, the serious danger is hemorrhage. If this is venous it may be controlled by careful packing with gauze.

If the blood comes from the internal carotid the only chance for the patient's life lies in the control of the artery in the neck until it can be ligated. When there is a fracture of the tympanic cavity involving other important structures already specified, Ramsey, Grant, Whale and West(1) consider that the chief danger is meningitis from extension of the infection to the meninges. Hence a wide area surrounding the external auditory canal should be rendered sterile and the utmost asepsis exercised. Grivot(1) declares that injury to the middle ear may be overlooked when there is severe traumatism of other structures, and may be made more manifest only when the latter has improved.

III. MASTOID PROCESS.

Direct wounds of the mastoid process, like those of the external auditory canal and tympanic cavity, are usually associated with wounds of important adjacent structures. They may result from the emergence of projectiles which enter through the face, neck or shoulder, but often they constitute the entrance passageway of projectiles directed forward, upward, downward or inward.

They include grazing wounds, compound comminuted fracture of the process, associated with fracture of the adjacent bone structures or extensive destruction of all or part of the mastoid cells, petrous bone, temporomaxillary articulation and cervical and intracranial structures. Depending on the severity and extent of the lesion the cervical nerves and vessels, the facial nerve, the labyrinth, middle ear, lateral sinus, meninges, cerebellum and temporosphenoidal lobe may be involved. The projectile may penetrate beyond the mastoid process or may lodge in the cells themselves. This applies to fragments of shells and of clothing and to missiles *whose force is largely spent*. Most of the injuries are direct *and compound.*

The chief danger is infection which is favored by the structure of the mastoid process and its communication with the middle ear and nasopharynx and the laceration of the tissues which accompanies these wounds. In addition to the usual wound and middle-ear infections the observer must be on the lookout for an osteitis that is often out of proportion to the injury and for an osteomyelitis which may supervene. Later complications are labyrinthitis, extradural abscess, cerebellar abscess, meningitis and thrombosis of the lateral sinus. The facial nerve is frequently involved.

Treatment.—Unless the wound is of the grazing type, with little secondary inflammation or infection, a mastoid operation will be necessary. If fragments remain in the bone, infection almost always follows and the operation is indicated.

The simple mastoid operation may be performed if the process and the foreign body are confined to the cells, but otherwise it will very likely be necessary to perform the radical mastoid operation. This is particularly indicated when the projectile is impacted in the posterior canal wall or penetrates to or beyond the middle or internal ear and when there is an old suppurative process present. Extensions of these operations may be called for in lesions involving the facial nerve, labyrinth, cranial floor, lateral sinus or temporomaxillary articulation.

Comment.

Souchet(1), who has made an extensive study of mastoid injuries, says that they are very common on account of the enormous quantity and the fragmentation of projectiles, and that infections may be maintained or increased by the presence of abnormalities or infections in the nasopharynx, nose and accessory cavities of the nose. He considers the diagnosis most important as to presence and location of fracture and projectile and complications. Facial paraly

complicating mastoid wounds have been reported by Beck(7), Alexander(5), Whale(3), Marriage(2), Wolff(2), Castellani(1) and others. Hemorrhage from the ear is a symptom according to Delorme(2), Denker(2) and Beck(2). Ramsey, Grant, Whale and West(1) say that wounds in the mastoid region, when they extend beyond the superficial portion, are apt to be accompanied by hemorrhage which may call for ligature of the internal carotid. Denker(2) reports a case in which a projectile lodged in the tip, Whale(3) one in which a bullet passed through both antra and nose then through the vertical ramus of the inferior maxilla, infringing on the anterior surface of the left mastoid, whence it was turned downward to the carotid sheath, and on autopsy was found lying exactly in the bifurcation of the common carotid. Closier(1) narrates a case in which a fragment of shell made a virtual petromastoid exenteration, raising up the cortex of the process, opening the mastoid cells, cutting away the external auditory canal and finally leaving the scene in front of the tympanum.

Bourgeois and Sourdille(1) found only 13 cases of wounds of the mastoid region out of 700 under observation at the Limoges Center. They divide these wounds as follows: (*a*) Tangential wounds, involving the external surface of the mastoid. (*b*) Excavating wounds due generally to large shell fragments which drive before them the superficial structures which at the same time reduce the penetrative force. (*c*) Penetrating wounds caused by projectiles which penetrate the tissues and remain within the mastoid or middle ear. (*d*) Wounds of transfixion caused by a bullet which enters the auriculomastoid region, and passes out in the auricular region of the opposite side. The mastoid process may be partially or completely shattered by the projectile which remains included within the mastoid or which continues its course beyond. The cells, antrum and aqueductus Fallopii may be opened and the internal and external cortex may be reduced to fragments which are

projected into the depths of the wound. The mastoid shattering causes fracture of the bony canal and of the peritympanic framework; the tympanic membrane is ruptured; the ossicles dislocated and the tympanum opened. The roof, the antrum and attic and the external labyrinth walls may be destroyed or fissured by the projectile itself or by the propagation of the mastoid fracture. In the latter cases the line of fracture, according to Le Mee, is above toward the squama, below toward the os tympanicum and middle ear, within toward the internal ear tending to isolate the mastoid process and semicircular canal from the petrous pyramid and the cochlea.

CHAPTER III.

INJURIES OF THE INTERNAL EAR.

THE internal ear may be injured in three ways:

I. Direct traumatism.
II. Traumatism by propagation.
III. Indirect traumatism.

I. DIRECT TRAUMATISM.

The internal ear is subject to direct traumatism very much in the same way as the middle ear, mastoid process and external auditory canal; in fact, its injuries are usually a part of a larger process involving one or more of these structures.

When the projectile has sufficient penetrative force it will pass through the petrous bone and shatter or destroy whatever part of the bone with which it comes in contact. If the force is more or less spent it will lodge within the bone structure.

In any event, whenever the internal ear is thus compromised by direct injury the result is an obliteration of its function. It is possible, of course, to sustain a direct injury without complete loss of function, but this is the great exception.

To the effect on the internal ear must be added that of injury to adjacent structures, of which the most common are the facial nerve, the jugular bulb, the internal carotid, *middle ear, mastoid* process and intracranial structures. In *the great majority of* injuries of this type the soldier is killed

or succumbs before he can be relieved. In those cases which survive the symptoms are escape of cerebrospinal fluid, hemorrhage from the ear, complete deafness, vertigo, vomiting, tinnitus, nystagmus and disturbance of equilibrium. Septic meningitis is a common complication and frequently results in death.

Treatment.—The treatment is that used for other wounds affecting the cranium when important structures are involved: absolute rest; as little manipulation as possible, except to remove detached fragments of bone, soft parts, metal, clothing; exploratory or elective operative procedures depending on the extensiveness of the process and the condition of the patient; and careful observation of the patient so as to anticipate and to treat complications.

It should not be forgotten that a small fragment may remain within the petrous bone for a long time without causing sepsis, but that infection is extremely apt to occur, particularly if the middle ear or mastoid is included in the wound. Facial paralysis and labyrinth symptoms do not call for immediate operation unless the patient's general condition warrants it, but the onset of meningeal symptoms indicates immediate operation if any good is to be accomplished.

On the whole, these cases present so many serious phases that only the most experienced otologic, brain or general surgeon can be expected to possess the judgment which their treatment requires.

II. TRAUMATISM BY PROPAGATION.

This refers to those cases in which the missile does not come in contact with the bony structures of the internal ear but in which they are involved by extension from injury made by direct traumatism to neighboring structures. This pertains especially to fractures of the petrous bone, which are either *transverse* or parallel to its axis.

The weak points of the petrous bone where fractures may be expected are at the floor of the external auditory canal, in the region of the tympanum, the cochlea, the carotid canal and jugular fossa, and it is here where the transverse fractures occur and the internal ear is commonly involved.

Fractures from the posterior fossa, projected toward the middle fossa, constitute the usual origin of this type of propagated fracture. The symptoms comprise loss of consciousness followed by deafness, subjective noises, vomiting, nausea and vertigo, increased by change of position, prolonged discharge of cerebrospinal fluid, with slight aural hemorrhage and facial paralysis as a rule. The disturbances of equilibrium disappear after a time, but the deafness may persist.

In the fractures parallel to the axis of the petrous bone, which usually accompany fractures of the middle fossa, succeeding an injury in the parietotemporal region, the middle ear is affected while the aqueduct of Fallopius and internal ear are free from trouble. In these cases the ear hemorrhage is greater than in the previous type and persists longer, and there is no escape of the cerebrospinal fluid. Deafness (less than in the former type) is present but no vertigo.

Treatment.—The treatment is largely expectant. The canal is cleansed of blood-clots and débris by the use of dry cotton, so far as possible, and sterile or iodoformed gauze packed into it. This is changed from day to day and careful attention given to any complication which may arise. Injections should be avoided even after suppuration appears on account of the danger of spreading the infection through the fissured bone. The imminence of a meningitis from an acute suppurative labyrinthitis must be considered, and when *necessary the surgeon* should not hesitate to operate on the *labyrinth.*

III. INDIRECT TRAUMATISM. LABYRINTH CONCUSSION.

Under this head are grouped those cases which result from traumatism propagated from adjacent structures from the explosion of shells in the neighborhood and from the constant detonations to which soldiers, especially artillery men, are constantly exposed.

This comprises an exceedingly large group of war accidents which, in part at least, are comparable to certain occupational concussions in times of peace.

Pathologic Anatomy.—There is a great deal of discussion as to the pathologic anatomy, for much of it depends on analogy rather than on autopsy studies. Naturally war conditions are not conducive to microscopic work and, furthermore, those in whom the symptoms of labyrinth concussion are manifested do not die until after the early condition disappears, or they succumb without exhibition of the symptoms.

It is recognized that the same cause may produce retinal hemorrhages and retinal detachment, and, from this, it is assumed that hemorrhage, detachment or laceration may occur within the internal ear, producing the symptoms of labyrinth concussion. Furthermore, there appears to be a marked difference in the results when the tympanic membrane is ruptured and when it resists the force, also when there is an old adhesive process present. When the tympanic membrane yields and is ruptured the labyrinth concussion resulting is less marked than when the force, severe as it may be, is propagated without rupture by the drum membrane and the ossicles to the labyrinth. When there is an old adhesive process present the concussion will be less because the cicatrized tissues conduct the force very poorly to the labyrinth.

The pathologic process which goes on appears to be a
follows:

Hemorrhages occur in the labyrinth, accompanied in the more severe cases by contusion of the membranous labyrinth which destroys the terminal sensory cells. This may be followed by atrophy of the neurons. In view of the fact that there is so little postmortem evidence of labyrinth lesions, some observers maintain that the symptoms depend on cerebral, cerebellar or general nervous concussion. According to others the explosions may cause an inhibition of the auditory nerve, as has been observed in the optic and olfactory nerves.

Etiology.—A great deal of work has been done in the investigation of the cause of labyrinth concussion. So far as relates to the labyrinth of animals brought within the range of explosives little has been determined, but some progress has been made in the study of the physical effects of these explosives. Thus it is held that the violent displacement of the air provokes an equally violent displacement of the drum, which is conveyed to the chain of ossicles and through the footplate of the stapes is transmitted to the fluid.

The mechanism by which the explosion works has been explained in this way (Sollier and Chantier, 1): All explosions are undulatory phenomena, the characteristic of which is the rapidity of the undulations which are propagated by radiation When a shell with retarded fuse explodes after being buried 50 cm. the gaseous expansion is vertical, the lateral effects being almost *nil*, and thereby the pressure is in the form of a cone with the apex below. The entire mass of air found in the cone is projected upward with a tremendous velocity, the walls being limited by the zone of radiation. At the interior a vacuum is formed which is succeeded by a thrust of the air from without inward. The man who is in the cone is projected with the mass of gas, and he may be severely lacerated, his clothes torn away or his cranium shattered. If he is beyond the limits of the cone the compression will be slight, but there will be an almost instantaneous decompression

the two phenomena succeeding each other rapidly. This action takes place from 3 to 5 meters, depending on the nature of the shell. A still further zone is from 5 to 10 meters from the explosion, in which the phenomena of vibration occur resembling those of electricity in rapidity and length, but they decrease and become extinguished at a very short distance.

Many hold the noise itself responsible for the condition, particularly when it is incessant.

Symptoms.—Most observers divide the cases into two groups, the mild and the severe, depending on the duration and character of the symptoms. Besides, they may be considered from the anatomic view-point, whether the cochlea or vestibule is involved with the corresponding symptomatic expressions. Furthermore, the symptoms are modified by the common presence of tympanic ruptures and psychic phenomena. The following constitute the more common symptoms of labyrinth concussion:

1. Loss of Consciousness.—This is the usual onset of the condition. The patient is thrown to the ground and remains unconscious for a longer or shorter period.

2. Deafness either complete or less marked is always present or it may remain permanently or it may continue for any period between these two extremes. The deafness is of the definite labyrinthine type, with abolition or marked reduction of bone conduction, diminution of auditory acuity, more marked for high- than for low-pitched sounds, Rinné positive, Weber lateralized to the sound or less diseased side.

3. Vertigo may be slight or severe, but it usually soon disappears more quickly than the deafness. This is presumably due either to the complete destruction of the labyrinth activity or to the greater vulnerability of the cochlea as *compared to* the vestibular tract.

4. *Tinnitus,* subjective noises, etc., disappear quickly.

5. Spontaneous nystagmus usually directed to the sound or least affected side is probably present immediately after the injury, but it is frequently absent when the patient is examined.

6. Disturbance of equilibrium disappearing early.

7. Nausea and vomiting.

8. Labyrinth Excitability.—This varies a great deal, in fact the caloric test does not give a constant result. Sometimes there is great hypo-excitability and sometimes persistent hyperexcitability.

9. The quality of the voice is often changed by reason of the fact that the patient can no longer hear himself talk.

10. General symptoms such as hebetude, loss of appetite, etc.

Diagnosis.—It is necessary to differentiate these cases from the psychic or hysteric cases and from simulation. The psychic and hysteric cases are characterized by a deafness that is apparently far more complete than in the concussion cases; there is no tinnitus, no nystagmus, no vertigo and no disturbance of equilibrium.

Prognosis.—Simple labyrinth concussion, as a rule, recovers in a few weeks, the milder cases without any loss of hearing. The severer cases may recover from all symptoms except deafness, which remains unchanged or increases. In like manner the cases due to the continuous noise from artillery, etc., may remain deaf.

Treatment.—Rest is the cardinal indication. The patient should be put to bed, being allowed to assume whatever position renders him most free from vertigo. All disturbing influence should be excluded. The diet should be restricted, small quantities of iced liquids administered if nausea be present. Iced applications or leeches should be placed over *the mastoid and* warm compresses over the epigastrium and *morphin if necessary.*

Later, potassium bromid may be administered as a seda-

tive, and strychnin not less than 15 mg. per day for the deafness. If the deafness persists the proper plans of reëducation should be provided for the patient.

Comment.

The literature of labyrinth concussion is exceedingly abundant. In the preparation of the foregoing the writer has drawn largely on the papers by Grivot(1), Lermoyez(1) and Fraser and Fraser(1). Grivot(1) states that the deafness of labyrinth concussion is likely to increase and Castex(2) considers the prognosis of concussion deafness very grave. According to J. G. Wilson(1) the concussion passes off with slight damage to hearing in many cases, though equilibrium disturbances may persist for a considerable period. The early recognition of the condition favors more rapid recovery of hearing. E. Weil(1) confirms the statement that in labyrinthine concussions the cochlear portion is more seriously damaged than the vestibular. On the other hand, Poyet(1) claims that the lesion usually extends to the whole labyrinth, manifesting the classical syndrome of Ménière: tinnitus, deafness, vertigo and vomiting. From Peyser's(1) studies it appears that vestibular phenomena were rare. The average period of recovery in his last 39 cases of labyrinth injury was one to three weeks. Experience has shown that the ear remains for some time at a point of lessened resistance, making it more susceptible to sound injuries. Alexander(1) states that traumatic deafness is curable in exceptional cases and only to a slight degree; galvanization of the eighth nerve is sometimes of service.

Jobson(1) studied a series of cases with the view of determining what effect gunfire has on normal ears. He examined 73 cases, excluding 13 on account of condition present which might influence the deafness. In the remaining 60 he found the condition of the drum as follows: Normal 37, dull

retracted 3, increased motility 2, cerumen removed 2. He concludes that exposure to gunfire in the present war often rapidly produces a permanent deafness.

Molinie(3) advises the use of the auditory palpebral reflex for the differentiation of labyrinth concussion deafness from the psychic or hysteric type and from simulation. It is based on the contraction of the orbicularis palpebrarum and other muscles resulting from a sudden noise near the tested ear. Lannois and Chavanne(3) consider that lesions of the internal ear or of the central auditory apparatus causing total bilateral deafness, which resist the usual treatment, are too grave to expect sensible improvement by auditory reëducation. Lip-reading furnishes the only truly useful agent for this type.

Grivot(1) states that reduction of the upper tone limit is characteristic of labyrinth concussion, and that when this is marked the prognosis is bad. He holds that sonorous vibrations or detonations may paralyze the auditory nerve by inhibition. Hoffman(1) found in patients suffering from labyrinth concussion from detonation a disturbance of sensibility of the external ear which was peculiar to affections of the sound-perception apparatus. This was manifest especially by the susceptibility of the meatus to warm and cold objects. Bourgeois and Sourdille(1) characterize the symptoms of labyrinth concussion as follows: Temporary and partial deafness of labyrinthine type; watch heard by air conduction but a short distance not at all by bone conduction; Weber lateralized to the unaffected side, Schwabach diminished, Rinné positive; loud voice heard at 2 meters or less, whisper only on contact or not at all; upper tone limit reduced. Abolition or marked diminution of labyrinth reflexes signifies a grave condition of the labyrinth, organic deafness and reserved prognosis. Conservation of reflexes implies relative functional integrity of the internal ear. If this coincides with marked deafness, it should

depend in part or altogether upon functional or hysterical trouble or simulation. The cochleopalpebral reflex is diminished. Lombard's deafening test does not cause an elevation of the voice and application of the test to the good or better ear is followed by an elevation of the voice. Disturbances of equilibrium occupy a secondary place in this condition. Some sway like a drunken man, some vomit for a couple of days, others only complain of a vertiginous state and nausea. After a short time no manifestations of disturbances of equilibrium are present. Bárány's tests show hyperexcitability, as a rule, but sometimes hypo-excitability. Subjective noises are exceedingly common and annoying. Auditory hyperesthesia and headaches are very common.

Mott(2) states that there are two hypotheses put forward to explain the organic lesions caused by commotion. While these refer to the general nervous system they have a bearing on labyrinth concussion: (*a*) Compression of the gas and atmosphere, so that the cranium and spine are struck, as it were, by a solid body and the vibration is transmitted through the bony structure to the cerebrospinal fluid and thence to the brain and spinal cord, causing a molecular disturbance of the delicate colloidal structures of the neurons, particularly those of the nuclei in the floor of the fourth ventricle where the fluid is the most abundant and where it acts as a water cushion upon which the vital cardiorespiratory centers rest. (*b*) Compression is followed by a corresponding decompression, causing liberation of bubbles of gas in the blood and tissues leading to embolism. Probably both forces of compression and decompression act in producing vascular disturbance in the central nervous system, causing arteriocapillary anemia and venous congestion. Fraser and Fraser(1) precede the report of their observations on the pathology of labyrinth concussion with the theories that have been held. (*a*) It has been asserted that when the drum-head ruptures there is less likelihood of injury to the labyrinth, but as these patien

exhibit marked or total loss of hearing some further lesion in the auditory apparatus must be sought. (*b*) It has been stated that hemorrhages occur in the peri- or endolymph space of the inner ear and that the delicate neuro-epithelial sacs and tubes of the membranous labyrinth are ruptured by the concussion of the explosion. It appears, however, that the structures of the membranous labyrinth are well protected from concussion because they are suspended in a lymph bath inside the hollow spaces of the bony labyrinth. (*c*) It has been suggested that in addition to these gross mechanical changes the explosion and the loud noise may destroy the delicate nerve-endings in the cochlea, paralyzing the hair cells in Corti's organ as the nerve structures of the macula in the retina are paralyzed by the rays of the sun in "eclipse" blindness, a paralysis or paresis following overstimulation. Some hold that change is a biochemical one and others that it is molecular. (*d*) It has been stated that the lesion is probably found in the brain; hemorrhages in the pons, medulla and cerebellum, involving the central connections of the auditory and vestibular nerves. Milligan and Westmacott suggest that it is due to a temporary interference with the neuron connection in the higher brain centers. The writers' study comprised the histologic examination of six specimens (4 of shell-deafness). The only changes of importance found were rupture of the drum-head and hemorrhage into the middle-ear spaces and hemorrhage in the fundus of the internal meatus. These findings rather confirm the functional theory, although the hemorrhage must have been responsible for some of the loss of hearing, tinnitus and vertigo. Scott(1) in an autopsy on a soldier who became deaf from a bullet wound of the vertex of the skull found an extensive blood-clot throughout the right tympanum and traces in the left but none in the labyrinth. Prenant and Castex(1) experimented with guinea-pigs and rabbits which they made deaf by detonation. From these they conclude

that the violent concussion produced by shell explosion causes lesions in different parts of the cochlea, particularly in the first and second turn. The organ of Corti is often lacerated, the pillars dislocated, external acoustic cells displaced and Hensen's cells overturned or displaced. Grivot(1) maintains that a cicatrized drum will yield more readily than a normal drum and will thereby protect the labyrinth more than the latter. The tympanic accommodation or the tension which is produced when the soldier is not surprised by the explosion is of service. Furthermore, a bent canal and cerumen lessen the degree of injury. Niel(1) from a study of 30 cases concludes that patients who have had a middle-ear disease before the war give a larger percentage of labyrinth complications than those without such history. Torrigiani(1) maintains that the cochlea and never the static labyrinth is affected when the injury is not limited to the tympanic membrane and the middle ear, due, he thinks, to the anatomic structure of Reissner's membrane and the sensorial epithelium of the anterior labyrinth being less resistant to trauma. In none of his 200 cases was there an abolition of the caloric reaction while all degrees of diminution of the cochlear function were encountered. Caldera(2) notes that no lesion of the middle ear is sufficient to constitute a predisposition to labyrinth lesions from acoustic trauma. Got(1) confirms the view of Lermoyez(1) that those who have sound ears are more susceptible to labyrinth disturbances than those with diseased ears. His statistics are as follows: (*a*) traumatic labyrinthitis without objective lesions of the middle ear, 144, or 50.88 per cent.; (*b*) traumatic labyrinthitis, with lesions of the middle ear, occurring at the time of the injury, 74, or 26.15 per cent.; (*c*) traumatic labyrinthitis, with middle-ear lesions acquired before the war, 65, or 22.97 per cent.

Lannois and Chavanne(4) claim that the action of detonations in the production of labyrinth concussion may be influenced: (*a*) by tympanic accommodation placing th

membrane under the most favorable condition for resistance if the patient is prepared; (*b*) by the state of the auditory canal, direction, character of the opening and cerumen; (*c*) by the state of the tube and middle ear, soldiers with previous ear trouble being specially predisposed. Meyer zum Gottesberg(1) did not find that the internal ear was less affected when the drum was ruptured by the explosion. Jones-Phillipson(1) believes that the greatest effect on the internal ear is produced through an intact membrane and one which stands the force of the explosion, and that the effect is less when the membrane lacerates and still less when there has been previous loss of the tympanic membrane.

Zange(4) reports 2 cases in which there was injury of the auditory nerve, in 1 case without injury of the middle ear and in neither case a facial paralysis. Hofer(2) relates 3 cases in one of which, although the wound was in the immediate vicinity, the cochlea and vestibular apparatus functionated normally; in another a partial lesion of the cochlea was present without any involvement of the vestibule and a third in which the entire cochlea was destroyed while the vestibule remained intact. Marriage(1) quotes Cheatle as reporting a case in which a bullet entered in front of the right tragus and emerged at a closely corresponding point on the left side, resulting in bilateral labyrinthine deafness. Challmet(2) reports a case of acute circumscribed labyrinthitis following a long time after an injury in a patient who had had an ear affection for ten years. The condition was relieved by operation. A patient with vestibular symptoms was examined by Beck(8) two weeks after he was subjected to labyrinth concussion. Although the caloric tests showed normal reaction the associated phenomena accompanying the rotation were abnormally violent. Goldmann(4) insists that all gunshot wounds of the head should be subjected to otologic examination. He states that in severe cases of labyrinth concussion the irrita-

bility of the vestibular apparatus is diminished or entirely lost for a period varying from a few days to several years. König(1) found no pathologic phenomena on the part of the vestibular apparatus in these cases. According to Lehmann(1) the majority of gunshot wounds of the temporal bones or cranial base are considered as purely surgical and do not reach the otologic department, although permanent damage of the auditory apparatus represents the principal persistent lesion.

Chatalin and de Martel(1) hold that the degree of disorientation in these cases can be established in some measure by the angle of deviation when vertiginous subjects of this type are made to walk with the eyes bandaged to a predetermined mark. Molinie(2) says that concussion-deafness is a sort of auditory dazzling which disappears little by little and that true and persistent labyrinth lesions are exceptional. Bourgeois(1) reports a case of secondary hemorrhage in the internal ear as a result of deflagration which he thinks caused a vascular alteration which finally led to the hemorrhage. Lannois and Chavanne(5) in 1000 cases coming under their observation found pure labyrinthine concussion in 262 cases, labyrinth concussion with tympanic rupture followed by acute otitis media in 301. Of these the pure labyrinth concussion were the most rebellious, 24 per cent. recovering in one month, 22 in two, 19 in three, 12 in four and others in five to nine months. Of the cases with suppurative otitis media the percentages were one month 16, three 20, four 10, and some in five, six and eight months.

CHAPTER IV.

PSYCHONEUROSES OF HEARING AND SPEECH.

UNDER this heading is included the large group of conditions brought about by the present war, which are manifested by loss or modification of hearing and of speech without discoverable causative lesions. They comprise the following types:

1. Deafness.
2. Deaf-mutism.
3. Mutism.
4. Stammering.
5. Aphonia.

They may be associated with other psychoneuroses and allied conditions, of which the following are the most common: blindness, paralysis, anesthesia, hypesthesia, hallucinations and other sensory or sensitivomotor alterations. In the severe cases there may be complete functional disorganization of the nervous system. Death may even result or the victim may be reduced to a state of imbecility.

These psychoneuroses come under the general phenomena of the so-called "shell shock," which comprises a set of symptoms varied as to detail, following the explosion of shells in the immediate neighborhood of the patient. These phenomena have been designated by different observers as hysterotraumatism, traumatic neurosis, psychic, functional or hysterical deafness, emotional shock, etc.

Etiology.—These cases, whose number is legion, have about *the same history. There* has been a severe explosion in the *immediate vicinity of* the patient, killing a number of his

comrades, and often, for a prolonged time, burying him in the débris of shattered structures. This is followed immediately by unconsciousness, and when he regains consciousness he finds himself deaf, speechless or affected by one or more of the symptoms to be designated. Exposure and hardship are not predisposing causes, but gradual physical exhaustion from great fear, lowered vitality from inadequate nutrition and the horrible sights that are frequently witnessed have a great causal influence.

Mutes, aphonics and stammerers all show some degree of improper respiratory gymnastics. Heredity and personal predisposition seem to favor the development of the symptoms, but age, race and occupation do not appear to influence it in any way.

A very reasonable hypothesis offered by way of explanation is to the effect that being deafened or made speechless by the noise of the explosion when the patient regains consciousness he is so disturbed by the chain of events culminating in his unconsciousness that he remains psychically deaf or mute, as the case may be.

Pathology.—No organic changes are found; in fact, some observers hold that the presence of a wound prevents its occurrence. The suddenness of the onset and the cure in many cases speak against any material lesion.

Some attempt has been made to show that cerebrospinal concussion is responsible, but no definite lesion has thus far been demonstrated.

Symptomatology.—In presenting the symptoms those pertaining to the functions of ear, nose and throat will be discussed in detail; for the long list of neuropathic and psychic symptoms which accompany them the reader is referred to manuals on neurology.

1. Loss of Consciousness.—This is invariably present; in fact, it is the first symptom manifested. Its duration varies, but it is usually prolonged.

2. Deafness.—When present, deafness is almost always complete and bilateral. When unilateral the ear which was toward the explosion is affected. The chief characteristic of the deafness is its completeness, which manifests itself by absence of all perception of sound, including the tuning-fork, which is heard neither by air nor bone conduction. The complete deafness is very suspicious of a psychoneurotic basis, as complete organic, labyrinthine deafness is extremely uncommon. If the patient can speak his voice remains normal for months, differing in this respect from deafness from other causes. Although the cochlear function is inhibited the vestibular symptoms are usually conspicuously absent.

3. Deaf-mutism.—In many of the patients mutism is associated with the deafness. It is usually also complete, although sometimes the patient makes a great effort to speak, which is unsuccessful, showing that the condition is a motor rather than a sensory aphasia. As a rule speech is restored before the hearing.

4. Mutism.—Some are mute without being deaf; however, the mutism is of the same type as that which is associated in deaf-mutism. In the progress toward resolution the mutism is often replaced first by aphonia and then by stammering and afterward by satisfactory speech. The essential feature of the mutism is its absolute character; the patient does not utter a sound; he cannot whistle. While he does not speak he still has memory for language, for he can read and write.

5. Stammering is usually transitory, though it may persist for some time. It is especially common in old cured stammerers.

6. Aphonia does not materially differ from the hysterical aphonia observed in civil life.

7. *Hebetude is marked* in those patients who appear listless *and indisposed to all* effort and broken in spirit.

8. Anesthesia and Hypesthesia.—These stigmata are extensively found when sought. In deafness the meatal region and even the entire auricle may be anesthetic or hypesthetic. The pharynx is commonly hypesthetic and the larynx may be similarly affected. Other areas of anesthesia are also found.

9. Eye Symptoms.—Blindness may be the dominant symptom. There is commonly a reduction of the field of vision or hemianopsia.

10. Other Ear Symptoms.—Vertigo is uncommon, loud subjective noises may be heard, and sometimes there are auditory hallucinations.

11. Other Respiratory Symptoms.—There is almost always disturbances in the respiratory function in aphonia and mutism. The respirations are short, the amplitude feeble and the chest expansion much below the normal. Sighing, yawning and similar respiratory efforts are almost always absent and cough short and aphonic. Laughing, moaning and weeping are suppressed and the tears fall on an expressionless face.

12. Loss of memory of events before or at the time of the accident.

13. Hyperacusis is a common symptom which often makes the patient very miserable on account of the extreme sensitiveness to sound.

Diagnosis.—The signs of these conditions are so significant that the differential diagnosis except from simulation and exaggeration offers but little difficulty.

1. Labyrinth concussion occurs under circumstances very similar to those of deafness from psychoneurosis. Both are inaugurated by unconsciousness which is succeeded by deafness, severe headache, vertigo, nausea, vomiting severe tinnitus and spontaneous nystagmus in labyrinth concussion. In psychoneurotic deafness, headache is uncommon or transitory, vertigo exceedingly uncommon, nausea and vomiting, *spontaneous* nystagmus absent, tinnitus seldom complained

of, but the deafness is complete, while in labyrinth concussion there is always some sound perception remaining. In labyrinth concussion the stigmata commonly found in hysteria are absent and there is no association with mutism, blindness, etc. Those deaf from psychoneurosis do not put their hands behind their ear when addressed; they regard the lips of the speaker with a fixed and unintelligent view as if they had never before heard speech.

2. Simulation and exaggeration constitute a much more difficult problem in diagnosis. They are discussed in another chapter, page 127.

Prognosis.—The prognosis is almost invariably good, provided appropriate treatment is administered, and provided they have not been subjected to various indiscriminate methods of suggestion. As a rule speech returns first and later hearing if they have both been absent. As the speech improves it is likely to pass through the various stages from mutism to normal speech: first whisper, then stammering and finally normal phonation.

Treatment.—In the early period of the war almost every conceivable form of suggestion treatment was used, with many reported successes. Some of the more common were the following:

1. Anesthesia.—Ether is administered to the patient, and when he is recovering he is aroused suddenly and thus discovers that he is no longer mute or deaf.

2. Sudden Awakening from Sleep.—In a similar way if the patient is suddenly awakened he discovers that he can hear or speak.

3. Electricity applied as usual in hysterical aphonia.

4. Hypnotism is successful in some cases.

5. Distracting the patient's attention in various ways, as, for instance, using a deafening instrument, and then as he follows the lips of the physician in repeating his words, allowing him to hear his own voice.

The best plan of treatment now in use comprehends the following:

1. These patients should be examined as little as possible. Every effort should be made to keep them from being too much concerned about their condition. Such are apt to become exaggerators if not simulators. Those who have made the rounds of various hospitals are very difficult to cure.

2. General hygiene, hydrotherapy and exercise are of great importance. The patients should be placed under the very best surroundings and with the best direction possible. Remedies appropriate to the conditions should be administered.

3. While the various methods of suggestion are of the greatest service in competent hands it must be repeated that they may be injurious or ineffective under other circumstances.

4. Reëducation, modified to suit the condition is the most effective and certain method now available. It is described in Chapter V, page 57.

Comment.

Wiltshire(1) offers the following conclusions as to the etiology of these conditions: (*a*) The wounded are practically immune from shell shock, presumably because a wound neutralizes the action of the psychic causes of shell shock. (*b*) Exposure and hardship do not predispose to shell shock troops who are well fed. (*c*) While it is theoretically possible that physical concussion resulting from a shell explosion may cause shell shock, it is certain that this must be regarded as an extremely rare and unusual cause. (*d*) Chemical intoxication by gases generated in shell explosions cannot be more than a very exceptional cause of shell shock. (*e*) Gradual psychic exhaustion from continued fear is

important disposing cause of shell shock, particularly in men of neuropathic predisposition; in such subjects it may suffice to cause shell shock *per se*. (*f*) In the vast majority of cases of shell shock the exciting cause is some special psychic shock; horrible sights are the most frequent and potent factor in the production of this shock; losses and the fright of being buried are also important in this respect; sounds are comparatively unimportant. (*g*) A consideration of the causes and frequency of relapses favors an original cause of psychic nature. (*h*) Any psychic shock or strain may cause a functional neurosis provided it be of sufficient intensity relative to the nerve resistance of the individual. Such shock or strain need not have any connection with sex "complexes."

Hurst(1) considers these cases of autosuggestion. The momentary deafness which is the natural result of the terrific noise of the explosion may make such an impression on the mind of the soldier that on coming to himself his first thought is of his hearing, and he may be so convinced that he is permanently deaf that he becomes deaf by autosuggestion. Happich(1) holds that apparently no one is safe from hysteria during the war. Three groups of hysterics can be distinguished at the front: (*a*) Men of low intelligence who have poor resistance against life at the front; (*b*) men of healthy appearance who arrive at the hospital with definite symptoms (aphonia, etc.), in whom recovery follows energetic treatment; (*c*) unstable neurotic individuals. Westphal(1) asserts that in addition to the shell-shock factor there is always a lesion present in psychogenic deafness. Massei(1) reports a case in which the hysterical mutism came on in a dream while in the hospital for a wound of the hand. Awakened by his dream of a conflict in which three of his comrades were killed he attempted to cry out but could not speak.

F. Brunetti(1) considers the hypesthesia of the skin and *the changes in the visual* field as indicative of hysteria. *Vonne(1) calls attention* to the fact that the severest

wounds fail to show any neurotic reaction, while he has found evidence of grand hysteria in mutism, stammering, isolated clonic spasms of the muscles of the throat and extremities and monoplegia and hemiplegia. Zange(5) states that the hysterical deafness may be associated with organic deafness from direct or indirect injury. Liebault(3) differs from other observers in holding that these patients have no fear; his material constituted 15 mutes, 52 aphonics and 8 stammerers. Lumsden(1) thinks that all these cases come under the heading of several disorders familiar before the war: (*a*) Neurasthenia due to lack of "ergogen" in the brain cells; (*b*) hysteria or subconscious malingering following emotional shock; (*c*) malingering of a purely conscious nature; (*d*) various combinations of these. Milligan and Westmacott(1) hold that laryngeal examination demonstrates that these cases of aphonia are not hysterical in origin but neurotic or functional, due to sudden arrest of the volitional impulses necessary to produce speech. There is a synapse somewhere, probably in the cortical cells of the center of speech, precluding the transmission of nerve energy requisite to set the machinery of speech in motion. Mott(1) thinks that mutism is caused by fear, producing an emotional shock, depressing the activities of the whole of the cortical substance connected with phonation and the production of audible sounds. de Sandro(1) maintains that aphonia, unlike mutism, does not depend on a central change but upon a functional paralysis of the vocal cord without anatomic changes. Kenyon(1) advises against the acceptance into the army of stammerers who have been cured, on account of the likelihood of recurrence under the influence of shell shock. Liebault(1) says some of the cases of aphonia come on gradually without shock.

As showing some of the vagaries of the symptoms, Zange(5) reports the case of a man whose hearing was completely lost for the tuning-forks in the entire series but who could hear loud conversation one-half meter away. Beck(8) reports

case in which labyrinth symptoms such as vertigo, uncertain gait, diminution of hearing, with normal caloric reaction and functional hemianopsia, were present. J. G. Wilson(3) saw 250 cases of shell shock while at the Ypres salient and on the Somme, in only 50 of which there was any complaint of deafness, and of these only 17 had actual nerve-deafness. According to Birkett(1) these men are very pathetic; they are broken in spirit, their nerves shattered and, according to Mott(1), most of those suffering from mutism make no sound when they attempt to cough, laugh or whisper, and sometimes there is difficulty in putting the tongue out, and in one case there was difficulty in swallowing. Sollier and Chartier(3) maintain that besides phonation and respiration other functions are changed; the constrictors may be paralyzed, the cords, widely separated, remain in the cadaveric position, although respiratory dyspnea is never observed. The muscles of the lower part of the face may be considerably diminished in activity and the patient does not find it easy to open his mouth; he cannot contract the constrictors of his lips nor the buccinators; the tongue is immovable and mastication is slow and fatiguing. Paralysis may be accompanied by contracture. The muscles of the pharynx and palate may be similarly affected; the muscles of the neck are in the state of hypofunction. The cutaneous sense is weak, taste and touch diminished; hypesthesia is present, at least around the mouth, chin, and anterior surface of the neck, but may be extended much farther. They describe a spasmodic stage which indicates a return of function. The improvement may be slow and progressive or by leaps and bounds, when it is almost always accompanied by crises. In deafness and deaf-mutism caused by war psychoneurosis the auricle, temporal and mastoid region, external auditory canal and membrana tympani present more or less marked anesthesia. These conditions may be associated with alexia, amblyopia, reduction of the visual field; blepharospasm, photophobia and

ophthalmoplegia. Gaupp(2) finds that traumatic hysteria of war inclines to marked psychomotor reaction, showing itself in the form of cramp, paralysis and tremors. Sarbo(1) claims there are two forms of symptom-complex present: (*a*) unconsciousness followed by loss of hearing as well as tinnitus and vertigo and sometimes symptoms of vagus paralysis appears; (*b*) unconsciousness followed by amnesia, slowing and halting speech, unilateral paralysis and sensitiveness to pressure over the parietal. West(1) has found that both limits of the auditory field are more or less contracted in these cases. Roncorini(1) observed, among other symptoms, muscular hypertonia, especially of the lower limbs, automatic movements, with rhythmic movements of the head, and exaggeration of the superficial and deep reflexes.

Zange(5) lays stress on the contradiction of symptoms as pointing to a psychoneurosis basis, and Canuyt(3) on absolute deafness, unchanged quality of the voice, absence of spontaneous vertigo, emotional state, bad emotivity, tremor, disturbances of sensibility, hysterogenetic zones and reduction of the field of vision. Hurst and Peters(1) make the following distinction between organic deafness and deafness from hysteria or malingering: (*a*) History: Severe deafness following explosion of a powerful shell is generally hysterical, though a lesser degree of deafness may come from rupture of the drum or tympanic hemorrhage; it is doubtful if absolute deafness ever results from internal ear hemorrhage following shell shock. (*b*) Bone and air condition: These tests are only of value in the slighter cases, as in many cases the deafness is absolute. (*c*) Auditory motor or jump reflex: This reflex continues in certain neuroses of emotional origin during sleep and deep hypnosis, although the patient does not hear the noise that induces it. A slight reflex was present in most of the cases of hysterical deafness. (*d*) Persistence during sleep: Babinski regards this as a definite law, that as hysterical symptoms are due to suggestion they should not persist

during sleep; deaf-mutes of this type may talk in their sleep. (*e*) Effect of hypnosis: It was found impossible to make two patients suffering from hysterical deafness speak or hear, although they were both deeply hypnotized. (*f*) Change in the voice: Nothing abnormal in the speech was discoverable in any of the patients deaf from hysteria. (*g*) Vestibular reaction may be altered in organic deafness. Putelli's(2) diagnostic points are diminution of the conjunctival, pharyngeal and laryngeal reflexes, anesthesia or hypesthesia of the membrana tympani, but their absence is not conclusive. Important is the presence of the cochleopalpebral reflex even when the patient does not hear anything.

Bourgeois and Sourdille(1) state that the evolution of hysterotraumatic deafness does not obey any fixed rule. It varies with the mentality of the subject, his good will, his intellectual and moral stability, the intensity of the emotional phenomena, his social sphere and the method of treatment used. An intelligent man with good will and self-respect and a desire to recover, will improve rapidly if he does not fall in the hands of an aurist who finds an imaginary lesion or inflicts improper local treatment upon him or practises harmful suggestion upon him. An illiterate man, anxious to quit his regiment or to return home who has become familiar with the disposition of deaf soldiers by the State, will not recover unless he is subjected to the most painstaking professional attention. McBride(1) holds that hysterical deafness may be suspected where the history indicates a chain of circumstances which the experienced observer is not inclined to consider sufficient to account for the great amount of deafness. Until further proof is forthcoming he is disinclined to attach supreme importance to the presence of vestibular reactions as an aid to the diagnosis of hysterical deafness.

Ranjard(2) says that the diagnosis between organic deafness *and neuropathic* deafness is exceedingly important, as

the former is to be treated by auditory reëducation and the latter by psychotherapy. MacMahon(1) says that mild cases of stammering may be relieved without treatment, for the condition disappears with the patient's improved condition. Patients suffering from aphonia should be put at complete rest in a hospital, and as the general health improves, treatment may be directed to the loss of voice. Hurst(1) considers that hysterical mutism is easier to cure than hysterical deafness, because the patient can be induced by reëducation to use the muscles involved in speech.

O'Malley(6) recommends that cold water be used to produce nystagmus and vertigo and then the physician should say to the patient through a long tube, "You hear now." This is often successful. Lannois and Chavanne(4) report that of 32 cases of deaf-mutism 15 were cured in a single séance. Citelli(1) states that etherization will relieve 40 to 50 per cent. of this type of speech and hearing defects, but that when the functional inhibition is very strong and when the ether causes no stage of excitation no benefit will result. He uses two other methods. (*a*) The larynx and hyoid bone are grasped firmly with the right hand as if threatening to choke the patient, at the same time asking him questions in an excited voice. (*b*) With great seriousness the patient is told (written if he is a deaf-mute) that on a certain day he would be cured by an operation, a serious one, possibly a fatal one, unless he recovers his voice before that time. If he does not a great play is made as if to force him to the operating table. This succeeds often when ether fails. Mauclaire(1) met with a case in which speech returned during a hysteriform crisis. Liebault(3) expresses no great confidence in the hypnotism treatment and advocates reëducation. Lombard and Baldenweck(1) utilize a noise maker in both ears of the patient who is to repeat the words of the physician. By diverting the instrument slightly without the knowledge of the patient he is allowed to hear his own voice

and the cure is effected. Mott(1) found hypnotism successful in the cure of mutism. Bilancioni(3) advises the use of ethyl chloride for the anesthetic treatment of these cases. Lortat-Jacob and Buvet(1), considering that the condition is an hysteric psychoneurosis, claim that a cure may be effected by provoking a crisis; for instance, ipecac is given, and in the midst of the crisis the deaf-mutism disappears. Böttger(1), on account of the coincident hypofunction of respiration in aphonia, makes successful use of artificial respiration by electricity in treatment. Morestin(17) in a case of hysterical mutism associated with wound of the tongue relieved the condition by manipulating the tongue. Dawson(1) found alcohol of service in a case of mutism of three weeks' standing that could not be relieved by etherization. Muck(1) uses the so-called bullet method to relieve severe functional aphonia, producing a transitory suffocation and impelling the patient to cry out in distress. Marcelli(1) reports the case of a soldier who had lost his voice after unconsciousness lasting three days. He regained his voice after he awoke himself from a dream of the bayonet attack responsible for his condition, with the battle-cry "Savoi!"

Fazio(1) claims that the anesthetic plan of treatment was first used in 1820 (chloroforma narcosis) and that he himself reported at the Congress at Naples, 1897, a number of cases cured by this method. He believes that etherization does not act by suggestion but by obscuring the consciousness and the mentality of the patient, so that he may be withdrawn from the inhibitory influence of a falsely acquired conviction and from the fixed idea that he cannot speak. Penhallow(1) demonstrated the value of etherization in a man who, after being unconscious, was deaf, dumb and blind. A few days later he regained his sight and could hear in one ear. Three months later, under ether, he recounted in a loud voice his experiences at the time of his accident and when he recovered from the ether his speech was normal. Tilley(1) used intra-

laryngeal faradization successfully in a case of aphonia. Hurst and Peters(1) and Nonne(2) favor hypnotism as a treatment. Putelli(2) succeeded in relieving some cases by putting the laryngoscope in position and asking the patient to repeat the sound "e," which he himself spoke in a loud voice. He believes that etherization is the best agent, that the cases should be treated at the front and that reëducation should be reserved for those organically affected. Massei(1) agrees with the advocates of etherization while Urbantschitch(1) records cures from faradization in hysterical deafness and mutism. Got(1) feels that when once the diagnosis of hysteria is made the patients should be sent to a neuropsychiatric service for treatment, particularly as their susceptibility to suggestion is well established. Each examination or each attempt at relief without success is apt to postpone or to prevent recovery. The method of Dub(1) consists of the following: In a case of combined deafness and mutism the deafness is first removed. For this purpose the patient is shown a slate on which is written that first his hearing will be reëstablished and then his speech. He is then taken into a dark room, where his eyes are bandaged. The head support is tightened so as to produce the sensation of an iron circle around the head. Now the light is turned on again, and the operator passes two ear catheters (No. 2 or 3) through the two lower nasal passages to the opening of the Eustachian tube. The catheters are fastened to the head by means of a string, or they may be held with the hand. Electricity comes next. One pole is led to the ends of two catheters and the other pole alternately to the mastoid process, and the faradic current is allowed to pass through. The current may be very weak. The hearing often returns on the first application, otherwise the current is repeatedly passed through, but always with interruptions, only a fraction of a minute's action *each time being* required. After the patient can hear, which *he shows by* gesture before being asked, the second part

the treatment begins: The catheters are taken out but the eyes are left bandaged. A catheter bearing at its lower end a sponge moistened with five drops of bitter tincture (tinctura amar acid) is introduced through the esophagus into the stomach. The two poles are then applied externally to the left and right of the larynx and the faradic current is passed through precisely as with the catheters. The patient is first instructed to intonate the vowel *a* and is then asked to speak sentences. He is then put to bed for twenty-four hours in a darkened room. For the further improvement of this psychogenetic condition the patients are detained a few weeks longer and daily reading exercises are instituted.

CHAPTER V.

RECONSTRUCTION AND REËDUCATION.

No phase of medical or social activity brought about by the present war has shown such an amazing development as reconstruction and reëducation. In anticipating the effects of modern warfare on the structural, social and functional factors of the combatants at the very outset plans for restoring them or for supplying their deficiencies were inaugurated. As a result the large movement, known as reconstruction and reëducation, has been fostered and extended until now it has achieved a high place in humanity, therapy and utility.

I. RECONSTRUCTION OF THE EAR, NOSE AND THROAT.

The great number of wounds of the face, head and neck has resulted in the obliteration or deformity of the organs in these regions. For the deformity and loss of substance of the external ear, external nose and face the plastic surgical procedures already in use before the war and those devised since are available.

For adhesions and stenosis of the external auditory canal and of the larynx the well-known methods described in this manual are used. The general subject of plastics, however, is assigned to another department, and hence it is not included in this manual.

II. REËDUCATION.

Reëducation may be applied to the correction of defects of hearing and speech by methods essentially different, both of which, however, requiring the closest personal attention and *observation*. In respect to its use as a therapeutic agent i

comes more or less in conflict with suggestion therapy, inasmuch as many of the cases with which the war has burdened the centers of reëducation have been of the type of psychoneurosis, hysteria, etc. Just as in civil practice during the past ten or fifteen years there has been a growing disposition toward the value of psychanalysis; in such cases there is a manifest leaning toward reëducation in preference to suggestion. While the latter brings forth many startling results they are less certain and less permanent than those from reëducation and are less free from the possibility of a vicious counter result.

III. REËDUCATION OF THE DEAF.

The principal of all sensory reëducation is the functional reawakening of its sense by its specific physiologic stimulus. The stimulus of the ear is the human voice, and its value is not denied by any masters of the technic of reëducation.

This point once admitted the method of application and its limitations and substitutes becomes a matter of much discussion.

The actual fatigue experienced by those who use the human voice for this purpose and the great limitation which necessarily is placed on instruction of this character have led many to devise instrumental substitutes for the human voice, some of which produce a sound resembling the human voice and others which make no attempt at any such resemblance.

Much controversy has followed the reports of the advocates of the various appliances not only in regard to the value of respective instruments but also to that of any substitute for the human voice in this particular. On the other hand, the advocates of the appliances claim that they possess the power of accurately measuring the quantity and intensity of the sound, impossible to any considerable degree with the human voice, and that they have a definite circulatory and kinetic effect on the auditory organs.

Considering reëducation as a whole it comprehends the following (De Parrel, 2):

1. Reëducation by voice, transmitted through the air or by tubes, phonographs or microphonic amplifying apparatus.
2. Sound massage by plates put in vibration by electricity, tuning-forks, sirens, etc.
3. Auricular and respiratory gymnastics.
4. Diathermia.
5. Lip reading.

The following are the most common appliances in use at the present time (Lannois and Chavanne, 2):

1. The tuning-forks of Rousselot and Natier give an extremely rich series of vibrations, from 32 simple vibrations to 8192 and with intervals up to 180,000.

2. The electrophone of Zund-Burguet utilizes metallic plates to produce sound. It is composed of three organs, producing sounds or registers making tones of different pitch and timbre. Each register is capable of producing a series of sounds up to about two octaves. The vibrating plate is fixed by one of its extremities, the free extremity supporting a block of soft iron, which is placed opposite an induction coil.

3. The kinesiphone of Maurice produces sonorous vibrations by means of monobranched tuning-forks which may be changed in length and tension by means of a lever. It is capable of producing from 80 to 3600 vibrations per second.

4. The vowel siren of Marage reproduces vibrations in groups of one, two or three according to the desire of the operator to produce the sound (French) of *I* and *OU*, *E* and *O* then *A*. It is composed of 5 coupled sirens whose movable plates are turned by an electric motor. These plates are perforated by triangular openings (*OU*, *O*, *A*) or rectangular and spreading (*E* and *I*). These openings are disposed in groups of three (*A*), in groups of two (O, E) or of one (OU, I).

5. The Meyer-Rowan instrument (Hubby, 2) has faradic hammers which strike on mica plates over four cylindr

chambers of different dimensions. These hammers cause the air in the chambers to vibrate, thus producing three different notes depending on the different sizes of the chambers. By opening or closing the connections with the other chambers the tones are varied in pitch. Rubber tubes carry the sounds directly to the ears.

Preliminaries.—All the methods of reëducation, whether vocal or instrumental, seek to hold and to increase the attention which is necessary for hearing and which is so easily lost by those who become deaf and also to develop whatever islands remain in the scale of hearing. To this end it is exceedingly important that accurate record be kept of the state and progress of the patient's hearing and of the associated body and mental condition. The character of the deafness is to be ascertained, its degree, its progressiveness, whether it is due to deformity of the external auditory canal, to a middle-ear process, to labyrinth concussion or to psychoneurosis, whether there is ankylosis of the incudostapedial articulation and whether paracusis Willisii is present. The patient's previous history must be investigated, his habit of life, his general health and his nervous state.

Types of Deafness Suitable for Reëducation.—1. Labyrinth Concussion.—This is the ideal group for reëducation, although some observers claim that rest and other medication will do as much.

2. Chronic suppurative or catarrhal otitis media in which the deafness has been increased by war conditions.

3. Deafness of Psychoneurosis Origin.—These patients respond readily to the reëducation plan by voice or appliance. There are those who believe that the benefit arises solely from the suggestion, others who can see no value in the *method* which they hold is inferior to the usual suggestion *methods of etherization*, etc.

4. Complete Bilateral Organic Deafness.—Lip reading *alone is of any value in* these cases when there is practically

no hearing left. There is grave doubt of its advisibility in any of the other forms of deafness.

1. **Technic with the Voice.** — At the beginning the séances should be very short, lasting but five to ten minutes. The words should be spoken into the ear loud enough for the patient to hear. Later on the tones may be lowered and, still later the whispered voice may be used. The distance from the patient may be varied while using the same intensity of tone, in this way securing the same effect as varying the intensity of the voice from a single position.

The attention of the patient should be cultivated, his interest stimulated and his efforts encouraged; only by persistence, assiduity and careful attention to details can any good be secured.

2. **Technic with Sonorous Appliances.** — Each school has its own scheme of action, but in the main they all depend on the enthusiasm and energy of the instructor, the use of instrument for a short period several times a day and the careful recording of progress day by day.

3. **Lip Reading.**—In this type of instruction quite as much as the others are enthusiasm, energy and intelligence of the greatest importance. As a rule the patient is ready and willing to give his fullest assistance, for this particular plan falls in line with his intuitive disposition to determine what is being said by watching the lips.

Trained teachers are necessary, and after the patient acquires some proficiency he should be placed under different instructors so that he may study a variety of lips. Except among the most ignorant or ill-disposed they soon acquire the necessary ability in this direction.

IV. REËDUCATION FOR SPEECH DEFECTS.

Reëducation is used for the following speech de*brought about by* war conditions.

1. Mutism.
2. Stammering.
3. Aphonia.
4. Altered speech from nose, mouth, pharynx and larynx wounds and defects.
5. Altered speech accompanying severe deafness.

Mutism may be accompanied by deafness, and stammering and aphonia may be stages of a resolving mutism. Defects of the mouth, pharynx and larynx from wounds may cause such a change in vocal production that the speech is unpleasant or largely unintelligible.

Psychoneurosis, which is the basis of most of the cases of mutism, stammering and aphonia, at the same time causes certain disturbances of motility and of sensation in other parts of the body. It is thus found that respiration is in a state of hypofunction, as are the lips, tongue, etc.

For this reason most of those who have studied these conditions, apply reëducation not only to the immediate correction of the speech defect but more especially to respiration and the muscles of the tongue, lips and mouth.

Preliminaries.—Before undertaking the actual treatment by reëducation it is important to make a careful examination of the larynx of the type of respiration used by the patient and to determine the respiratory capacity. Fluoroscopy is of great assistance in determining the movements of the diaphragm. The findings should be recorded and the progress toward resolution, by similar examinations, conducted from time to time. Everything should be done to improve the general health and well-being of the patient. He should be placed under the most advantageous surroundings, preferably far away from the scene of his accident, where he can have plenty of exercise, fresh air, etc.

Respiratory Reëducation.—This is the fundamental requirement for all types of reëducation for speech defects; the purpose is to establish or to restore a normal respiratory

function. This is achieved by various gymnastic exercises which will assure sufficient air capacity and air force for both normal respiration and speech.

Among those usually prescribed for this purpose may be mentioned:*

1. Lateral extension of the arms.
2. Vertical movement of the arms.
3. Bending the body to the right and to the left with vertical extension of the arms.
4. For gymnastics of the diaphragm the patient lies on his back and breathes through his nose or mouth in jerks, forming his lips in the position required for the letter *U*.

Reëducation of the Larynx.—In aphonia the cords approach one another but do not meet except in the arytenoid portion. As the patient attempts to phonate the larynx tightens and the ventricular bands are brought closer together, which has the effect of bringing the larynx higher than normal. The endeavor, therefore, is to return the larynx to its normal position. The patient is made to bend his head forward so that the chin almost touches the cervical region. The thyroid laminæ are supported between the thumb and index finger above and below. With the larynx held in this position it is very difficult for the patient to tighten the larynx and there is no strain on the thyroarytenoid muscles and hence none on the vocal cords.

The function of the larynx may be improved by external massage in the anterior cervical region by a hand electrical apparatus.

As the patient begins to utter sounds, care must be taken to prevent the larynx from tightening or being pushed up. The vowel sounds have been found to return in the following order (French): *O, E, EU, OU, U, I*.

* *The methods of reëducation described are drawn largely from Liebault and Coissard*(1).

Reëducation of Associated Muscular Actions.—Many victims of speech defect have incoördinate movements of the tongue, lips and face which require reëducation quite as much as the essential respiratory and speech organs themselves. Certain gymnastic exercises are prescribed for this purpose.

1. Exercises for the Lips.—(*a*) Exercises of resisting the lips in their movements of propulsion and retraction. (*b*) Advancement and recoil of the lips, more and more rapidly showing the teeth. (*c*) Gradual movement of the lips in the pronunciation of *A* (in far), *O*, *OU*. (*d*) Vibrating the lips.

2. Exercises for the Tongue.—(*a*) Exercises in resistance in the movement of the tongue. (*b*) Sticking the tongue out as far as possible in a flat position. (*c*) Sticking the tongue out as far as possible in a pointed position. (*d*) Sticking the tongue out and returning it rapidly. (*e*) Carrying the point of the tongue to the palate against the roots of the superior teeth and then toward the floor between the lips and the inferior teeth. (*f*) When the tongue is very thick and lacks in suppleness it is necessary to press it between the teeth at the point, when it is thrown out little by little.

Exercises for the Muscles of the Face.—(*a*) Opening of the mouth. (*b*) Closing of the mouth. (*c*) Opening and closing the mouth successively more and more rapidly. (*d*) Throwing back the commissure as in laughing. (*e*) Advancing the lips as in pouting. (*f*) Moving the point of the tongue from the mouth. (*g*) Drawing the tongue back again rapidly. (*h*) Carrying the point of the tongue to the palate to the right and left side of the mouth.

Altered Speech from Nose, Pharynx and Larynx Wounds and Defects.—The treatment of this condition is largely individual. Each case is a law unto itself. In the main it is taught by vowel exercises, syllabification and above all by persistence in well-considered efforts to enunciate normal sounds.

Altered Speech Accompanying Severe Deafness.—The methods used are those followed for this condition in civil life.

Prognosis.—Practically all the speech defects cases due to psychoneurosis, subjected to intelligent reëducation as suggested, recover after a short period. In the course of the improvement the patients may go through the different stages: mutism, aphonia, stammering and normal speech. Stammering often requires, in addition to the designated exercises, certain others which have been made known by instructors in this field. The results in organic defects of speech will depend on the degree and character of the defect, the industry and receptivity of the patient and the individual attention of a competent instructor.

Comment.

Reëducation of the Deaf.—De Parrel(1) suggests the term anacousia to designate the means employed for reëducation of the deaf and defines it as a science of both physical and physiologic origin which has for its aim the reawakening of audition by sonorous stimulation of the labyrinth, the regeneration of the tissues of the auditory tract by circulatory and kinetic action and the reëducation of the functions of auricular accommodation and attention by oral exercises. Castex(1) utilizes his institution for (*a*) instruction in lip reading; (*b*) reëducation for those who still retain some hearing; (*c*) autophonic exercises to overcome the change in speech accompanying severe deafness. Reëducation of hearing has a double result: maintaining of audition by means of the human voice and making the patient recognize by his auditory sensation shades of meanings which he neglects. Drout(1) holds that sonorous vibrations have the effect of *a true massage* which not only restores the suppleness or *motility, lost to* the membrana tympani and ossicular chai

but also activates the peripheral circulation and carries life into the diseased organs. In reëducation by the human voice the exercises are begun with sounds not entirely lost and the distance or intensity is gradually increased. Beginning first with isolated simple words, longer and more complicated words are gradually used. Tillot(1) recommends the following for the reëducation of the physical and moral sufferings of the severely deaf: (*a*) Sounds produced by different instruments, such as drum, bell, phonograph and piano. (*b*) Simple vocalization, best conducted to the two ears by acoustic tubes. (*c*) The auricular gymnastics of Fernet. (*d*) Respiratory exercises. (*e*) Lip reading. Maricella(1) prefers the natural voice with delicate and various modifications to the artificially imitated vowel sounds. Lannois and Chavanne(3) are opposed to the use of lip reading except when there is a lesion of the internal ear or the central auditory apparatus causing a total bilateral deafness. Marage(1, 2, 4, 7) is a great enthusiast for reëducation of hearing by instruments, more especially that devised by himself. He makes a very extensive record of the patient's condition and of the results of various tests at the beginning and in the course of treatment. The different types of 100 cases under treatment were: lesions of the middle ear, 19; cerebral concussion without lesions, 38; cerebral concussion with middle-ear lesions, 52. The results of the treatment with his vowel siren were: sufficient hearing to rejoin regiment, 68 (10 could not return on account of deafness); 22 who can hear when spoken to near the ear are available for the auxiliary army service. Lannois and Chavanne(2) doubt the value of Marage's work; in fact, they have little confidence in reëducation by instruments. Ranjard(2) and Kathariner(1) substantiate Marage's findings. Thollon(1) considers it absolutely necessary to conserve the remains of hearing in deaf-mutes by exercises with the spoken voice when the hearing is entirely gone. It is important to main-

tain the quality of the voice so far as possible by appropriate exercises. Putelli(3) opposes sending cases of hystero-traumatic deafness to special centers of reëducation. De Parrel(2) insists that the presence of paracusis of Willis absolutely demands anacoustic treatment while complete ankylosis of the incudostapedial articulation, with accentuated hyperacusis, impermeability of the tube, short Schwabach, positive Rinné and vertiginous antecedents, calls for a reserved prognosis but does not absolutely interdict the use of electrophonoid massage. He favors the creation of special hospitals for the deaf far from the city, in which special attention can be paid to the general health and in which the most effective technic can be applied in short séances, very mild and frequently repeated. J. G. Wilson's(2) plan for the totally deaf is as follows: (*a*) Tuning-forks are applied to the bone or through resonators attached to the ear by tubes or through the air. (*b*) The voice is used through resonators with tube in the ear, through speaking tubes or without any aid. (*c*) Each treatment period is short, for fatigue is rapidly produced; headache, vertigo, diaphoresis and pain may occur if the treatment is too long continued. (*d*) As soon as possible carefully graduated physical exercises are given. (*e*) As early as possible it should be ascertained if the semicircular canals are acting, as when there is reaction to caloric and rotation tests further treatment is justified. His conclusions are: (*a*) The normal stimulus (musical notes or voice) is an adequate stimulus for the nerve and is the best stimulus; electricity is contraindicated and likely to do harm, since it so easily produces vertigo. (*b*) In the totally deaf, bone conduction is perceived before air conduction; it is essential to differentiate vibrations from musical notes. (*c*) In these cases summation of stimuli plays an important part in the perception of sound. (*d*) There is a marked diminution of the duration of hearing along the whole series of forks, both through bone and air. This corresponds an

exists *pari passu* with concentric limitation of the fields of vision. Often both improve together. Frequently the field of vision is more retracted on the side having the greater deficiency of hearing. (*e*) As a result of the concussion due to high explosives there is frequently a trauma demonstrable in the ear. This may be accompanied by neurosis (traumatic neurosis), especially headaches and vertigo. The perception of sound is diminished over the whole normal range; the diminution may be so great as to abolish totally the perception of sound; while no tone islands have been found by the writer there is a diminution all along the scale both for bone and air conduction. (*f*) As the deafness diminishes there may persist for a long time an inability to grasp intelligently what is said or to retain the memory of it. Thus a word may have to be repeated two or three times before the patient gets it; or if he be asked to repeat two or three numbers given consecutively he will repeat the last one; he knows that there were others but did not get them. Mueke(1) expresses a rather gloomy view upon the value of instrumental reëducation of the deaf. (*a*) The only good that could result in suppurative otitis with no membrane or a large perforation would be by labyrinth stimulation, and the labyrinth is seldom at fault. (*b*) It is extremely difficult to imagine that drum vibration or vasodilatation could have any effect on the old scars and fibrous adhesions of suppurative otitis. (*c*) In otosclerosis little good can be expected except for the tinnitus. (*d*) In chronic catarrhal otitis media, while drum massage and vasodilatation are certainly beneficial, the physiologic massage must be of greater benefit. (*e*) No benefit can be derived in cases of nerve deafness. Lannois and Chavanne(2) succeeded in getting good results in lip reading in 32 cases out of 50 cases, fairly *good in 11*, mediocre in 2 and negative in 1, an illiterate *Corsican who could not* speak French. The time necessary *varies, but five months* is the average, being influenced by

the intelligence of the subject, his willingness, his physical condition and the pathologic lesion.

Reëducation for Speech Defects.—Belanger(1) discussing the change in speech following defects in the upper or lower jaw advises the following: (*a*) The treatment should be moral, material and psychical, and the patient should be informed that in spite of his mutilation he may again acquire serviceable speech. (*b*) The instructor should not permit the patient to be misled into improper methods of speech production by allowing him to make useless fatiguing and fruitless attempts. (*c*) The rhythm should be conserved as much as possible, and he should not be permitted to isolate words from one another, but instructed to bind them together. (*d*) He should make and act the exact method from the phonetic stand-point by which the various elements can be obtained in order to enforce precision, with exercises in syllabification in words and phrases. (*e*) The vowels should be first given as exercises. (*f*) So far as the articulation is concerned a close study of the organ that has been destroyed or affected will give useful indication as to the easiest method of inducing normal speech. (*g*) Equivalence should be sought for to replace the articulation, which is impossible to be secured under the circumstances. (*h*) When it seems absolutely impossible for the patient to pronounce the word after the instructor has repeated it several times it is very rare that by perseverance he will not be successful in achieving an approximately normal result.

Boeri(1) states that the technic of respiratory reëducation should consist of appropriate movements of inspiration and expiration, avoiding complex and fatiguing movements: (*a*) Extension of the trunk to fortify the muscles of the spinal column; (*b*) exercises of the arms and shoulder to favor expansion of the thorax forward; (*c*) exercises for the diaphragm, abdominal and lumbar walls, coördinating the movements of the diaphragm to produce a powerful

abdominal respiration. MacMahon(1) described shell shock stammering as a more or less severe inhibition of speech, accompanied in some cases by amnesia. The patient is first to be taught proper breathing and then the main vowel sounds and their resonator position, that is, the correct position of the tongue and lips and the distance between the teeth required for each proper vowel sound. These vowel sounds are then combined and words are given which contain no main vowel or compound sounds. The consonant sounds are then taught, both the breathed and voiced consonants. Several alliterative examples of each consonant are given and regularly practised and vowel combinations taught by examples. Fröschels(3) states that patients with total aphasia may be greatly improved in a sufficient length of time and that the prognosis should be temporarily based only on the patient's progress under treatment in the form of exercises for the reacquisition of speech. Garel(2), in order to cause the voice to persist after it had been recalled by suggestion, instituted special exercises in scanning words syllable by syllable, making the patient go through the classic arm exercises of respiratory gymnastics or recommending the patient to press the epigastrium with the hand as each syllable is pronounced. Marx(2) reports 67 cases of psychogenic speech disturbances, 56 of aphonia, 2 of mutism and 9 of stuttering. Nearly all had been treated with electricity without cure; 53 out of the 56 cases were cured by exercises to correct the breathing and suitable speech exercises. Liebault and Coissard(2) recommend that when a soldier has remained aphonic without signs of acute laryngitis he should be sent to a speech reëducation establishment. Sollier and Chartier(3) hold that, on account of the general exhaustion and cerebral obnubilation present at the beginning *in both psychoneurotic* mutism and deafness, no special treat*ment should be undertaken* until the patient has recovered *his strength and his* psychic function has been awakened.

CHAPTER VI.

MISCELLANEOUS

I. FACIAL NERVE.

THE facial nerve may be injured primarily by traumatism from projectiles, fragments of metal or bone or secondarily by infection or cicatricial inclusion. It may be involved in any portion of its course from the parotid region through the neck, stylomastoid foramen, aqueductus Fallopii, internal auditory meatus and cranial cavity.

The facial nerve may be injured in wounds of the neck and face and its passage through the aqueduct of Fallopius makes it likely to be injured in the external auditory canal, mastoid, middle-ear and internal ear wounds, as has already been shown.

The nerve may be severed completely, lacerated with a loss of substance or impinged upon by spicula of bone, fragments of metal and other extraneous substances. Whatever the injury the result is a paralysis, complete or incomplete, temporary or permanent, depending on the location and extent and character of the injury. Wherever improvement is possible, the prognosis is better the earlier the treatment is undertaken. Paralysis of the parotid portion is less serious but less easily repaired by anastomosis than that of the petrous portion, and the most obstinate is that of the second and third portions in the Fallopian canal.

Treatment.—The treatment is altogether surgical and consists in the following:

1. *Removal of foreign bodies, fragments of shell or spicula of bone. It is sometimes possible to liberate the nerve by*

removing these foreign bodies which press on the nerve in the Fallopian canal; they may be discovered while undertaking necessary operative procedures in the neighborhood or the operation may be made for this specific purpose.

2. Bringing the cut surfaces together with or without suture. In the parotid region when the wound has cicatrized the thick cicatricial tissue should be cut away and the severed ends of the nerve filaments put in approximation. If this cannot be done the wound must be sutured, layer by layer, in the hope of bringing the cut ends of the nerve filaments close enough to permit union to take place.

For injury of the nerve in the petrous bone a radical mastoid operation is performed, enlarging the tympano-mastoid canal as much as possible so as to bring into full view the osseous portion of the Fallopian canal where it emerges above from the fenestrum ovale. The thin bone covering is then removed, the bone being denuded from above downward. Moure advises that this procedure must be very precise, very sure and very delicate. When the nerve is fully exposed, whatever means of assuring union and resolution desired may be undertaken.

3. Implantation of other nerve fibers in muscles supplied by the facial. The hypoglossal nerve has been used for this purpose.

4. Anastomosis.—The various types are available in appropriate cases: facial hypoglossal, facial spinal accessory, etc. None of these operations should be undertaken except by those whose skill in work of this sort cannot be questioned.

Comment.

In the treatment of facial nerve paralysis due to war injuries, Moure's work stands out preëminent. According to Daudin-Clavaud(1), who worked under his direction, there were 17 cases altogether in his service; operation was

undertaken in 12 of these, with the result that 6 were cured, 4 were hopeful and 2 unaided. Haberland(1) details the method used by him for direct implantation of the hypoglossal into the muscles of the face for facial paralysis in one case as follows: The hypoglossal nerve is exposed with its terminal branches, then the paralyzed facial muscles are dissected out, especially those which lift the angles of the mouth. The terminal branches of the hypoglossal nerve are embedded in these muscles. In from seven to twelve weeks the first signs of success appear.

Moure(3) reports a case in which the facial was wounded by a ball passing through the petrous bone. Ten months later the facial, on operation, was found intact, but there was a small neuroma near the point at which the nerve emerges from the stylomastoid foramen. In another case, five months after injury, the nerve was exposed and found completely severed except for a small nervous filament. The two portions were united at the same level. Brindel(1) had a case of facial paralysis from fracture of the cranial base which was relieved by removal of the fragments of the crushed roof of the Fallopian canal. Beck's(7) case of facial paralysis, with complete deafness and rupture of the tympanic membrane, is unusual as a combination from indirect trauma.

II. NON-TRAUMATIC AFFECTIONS OF THE EAR, DUE TO WAR CONDITIONS.

There are many pathologic conditions prevalent in civil life for which the circumstance of war constitute a special predisposition. These pertain to the following agencies:

1. Lack of cleanliness and attention to personal hygiene.
2. Exposure to cold, dampness and sudden changes in temperature.
3. *Lack of rest.*
4. *Extreme* nervous tension.

5. Prevalence of infectious diseases.
6. Abnormal food conditions.

These are responsible not only for the development of acute and chronic ear affections but also for the recrudescence of affections which have resolved. The most important are the following:

1. Otitis Externa Acuta.—Infection of the external auditory canal is very common in view of the uncleanliness and the likelihood of infection under the circumstances.

2. Otitis Media Acuta.—Very favorable conditions are invariably present for the development of an acute catarrhal or suppurative middle-ear inflammation. This applies not only to the bad hygienic surroundings and the prevalence of infectious diseases but also to the predisposing conditions in the nose and nasopharynx, which are themselves augmented by the factors of war. The acute exacerbations of the chronic processes cured or still present fall readily under the same category.

3. Otitis media suppurativa chronica is extremely likely to progress when it is present or to reappear if it has resolved. Furthermore, complications are more apt to ensue.

4. Other Chronic Ear Affections.—The effects on these conditions is probably what would be experienced in civil life under somewhat similar circumstances.

5. Acute mastoiditis and other complications are perhaps a little more common than ordinarily, but they seem to pursue the usual course.

Comment.

As has already been stated, Royet(1) describes what appeared to be the ordinary acute suppurative otitis media, which he finds to be the result of a ruptured tympanic membrane which often occurred without the patient's knowledge. Brindel(2) found in 3100 cases admitted to his

service (1550 hospital cases) that 800 were affected with ear discharge (350 acute and 450 chronic), and mastoid complication occurred 108 times (78 to recent suppurations and 30 to exacerbations). His conclusions are: (*a*) Intracranial complications of otitic suppurations are very dangerous and surgical treatment is more efficacious from a preventive than from a curative stand-point. (*b*) Half of the complications may be avoided if attention is paid to the cure of chronic suppurations. A good portion of the other half will be prevented if early and radical intervention is undertaken as soon as there is any danger of mastoiditis. (*c*) Erysipelas in the course of an acute suppuration increases the virulence of the pathogenic germs and favors meningitis. (*d*) A discharge of the ear may be the cause of cerebrospinal meningitis. Lannois and Chavanne(4) report that out of 183 soldiers returned from the front on account of exacerbation of a chronic suppurative otitis media only 43 per cent. could be returned to the regular army service: 56 per cent. were placed in the auxiliary service and 1 per cent. was exempted. De Carli(1), who had felt that the Italian army orders discharging almost all those suffering from this disease was not justified, changed his opinion when he had charge of a service in which the wards were filled with patients of this class who had never even been in the trenches. Trible(1) does not believe that rupture of the membrana tympani is responsible for most of the acute suppurative ear conditions. He thinks that the common causes are the acute exanthemata, tonsillitis, acute pharyngitis and pyogenic affections of the nose and nasopharynx.

Friederich(1) suggests that furunculosis which deserves consideration by military surgeons should not be treated by unnecessary incisions. Molinie(2) claims that ear affections contracted in the army are 21 per cent. of the ear cases and that acute otitis media is complicated by mastoiditis in 7 or 8 per cent. Imhofer(1) says that the decisive features

chronic middle-ear suppuration in regard to military service are: (*a*) the seat and kind of perforation; (*b*) the presence or absence of complications. Objectionable are those perforations in which a fistula leads toward the epitympanic recess, the antrum or the mastoid process. The secretion discharged from the perforation is of primary importance, as it indicates the presence or absence of bone involvement. An abundant, even offensive, secretion is not a reason to designate a middle-ear suppuration as difficult to cure; nor should a slight secretion be interpreted as pointing to a benign and readily curable middle-ear suppuration. The existence or imminence of complications calls for relief from military service. Putelli(1) insists that the provision of the Italian army regulations rejecting those who have chronic secretive otitis accompanied by caries of the ossicles or other conditions difficult to remove, practically rejects all cases of chronic otorrhea, for they are always accompanied by caries either of the ossicles, tympanic ring, attic or wall of the tympanum. Zange(6) would not allow soldiers with suppuration of middle-ear mucosa (tubotympanic form) with perforation in the lower half of the tympanic membrane, which continues in spite of treatment, to go into the field. Canuyt(3) is of the opinion that mastoiditis, sinus thrombosis, meningitis and brain abscess are more common complications of chronic suppurative otitis media under war conditions than in civil practice.

III. EAR DEFENDERS.

In view of the great frequency of rupture of the membrana tympani, labyrinth concussion and noise-deafness brought about by the use of high explosives, efforts have been made to protect the auditory apparatus by various types of ear *defenders. It has been* fairly well established that the harm *results from the* greatly increased air-pressure first *transmitted to the tympanic* membrane and then through the *ossicular chain to the* labyrinth at the round window.

Complete obturation of the external auditory canal would not be acceptable, as it is necessary for the soldiers to hear the commands. Hence a great deal of ingenuity has been manifested to reduce the air-pressure or to deflect it from the drum, at the same time permitting sound waves to reach the labyrinth with sufficient strength for the purposes of audition.

The following are the types of defenders in use:

1. Cotton has been employed since it became known that explosions could cause labyrinth concussion. It is used dry or impregnated with glycerin and is inserted loosely or packed tightly in the canal. It is open to the objection that it either hinders the hearing or fails to prevent the concussion.

2. Appliances.—In order to withhold the pressure and at the same time permit the sound waves to pass to the drum and labyrinth, various appliances have been devised and put in practice. Some are exceedingly complicated, unwieldy and expensive. In the main they depend on a diaphragm which closes off the ear canal when the air-pressure becomes unduly great or on an irregular canal through which the pressure is reduced in passing. The most common types are the Mallock, Eysell, Verain, Ross. The British Tommy is virtually a small rubber, hollow nipple with a tympanic end, rounded and without an opening. The external portion is expanded like a flange. The appliances at present in use in the United States Army are the British Tommy and vaselin cotton.

3. Physiologic Aids.—Some protection is afforded by putting the fingers in the ears and yawning or opening the mouth at the time of firing or of explosion or swallowing strongly several times while the nose is compressed between the two fingers.

Comment.

Marriage, according to the *Lancet*(1), warns against the *use of celluloid for* ear defenders, as some have had their ears *damaged by ignition*. Caldera and Bella(1) object to cotto *which is a poor protector and renders the ear more deli*

and less able to defend itself. On the other hand, Weil(1) strongly advocates filling the ear with cotton and opening the mouth during the engagement of artillery. Wicart(2) favors the various physiologic aids, also covering the canal and mastoid with a pad of cotton, the canal previously having been filled with absorbent cotton saturated with glycerin. Eysell(Prevention, 1) considers cotton useless, for it affords no effective protection. He advocates a small plug, devised by him, which can be worn without discomfort. The appliance contains a cavity guarded by a metal valve which permits the transmission of ordinary sound but which closes automatically when the pressure is greatly increased by explosions. Verain and Verain(1) have devised an appliance made of celluloid or aluminum, in the shape of an olive perforated at either extremity, of proper dimensions to fit the external auditory canal. The detonation chamber made up of the interior of the olive is brought into relation with the atmospheric air and the air inside of the ear by two T-shaped canals disposed at right angle to the interior of the stem which passes through the olive following its large axis. In another model the interior capacity is divided into two portions by a thin celluloid septum pierced with a fine hole. One of the chambers communicates with the external ear by a stem and the other by a small hole. The three holes are continuous. Rogers(1) prefers an ear plug composed of plastic material held together by fiber and impregnated with antiseptics, and Mallock(1) has devised an appliance in which the group of parts forming the protective ear drum is fitted in a cylindrical ebonite holder. It consists of seven component parts, the most important being the sensitive diaphragm enclosed between the two wire gauze strips. Ross(1) employs an ear defender consisting of a light horseshoe-shaped spring with pads at each end and bound round with velvet or other soft material. The pads of the spring press on the tragus of each ear, the curve of the spring lying under the chin.

CHAPTER VII.

INJURIES OF THE EXTERNAL NOSE AND NASAL CAVITIES.

I. INJURIES OF THE EXTERNAL NOSE.

WOUNDS of the external nose may be limited to the external nose or may be associated with wounds of other structures. When they are made by a projectile striking transversely the external nose may alone be involved, the nasal cavities penetrated or the face and orbit included in the wound. When the projectile enters anteroposteriorly it is likely, according to its size, character and velocity, to wound the nasal cavities, the accessory cavities, the orbit, the nasopharynx and the cranial cavity, depending on its size, character and velocity. The injuries comprise the following:

1. Abrasions, contusions and slit-like wounds which are limited to the external nose.

2. Penetrating or perforating wounds which involve other structures. The bullet, fragments of metal, clothing, etc., may be lodged in the tissues of the external nose or in the nasal cavities, accessory cavities, orbit and more remote organs.

3. Detachment or destruction of part or all of the external nose. Wounds of this type are made by saber cuts or by large projectile or fragments of shells which still retain much of their propulsive force.

Treatment.—In the treatment of wounds of the external nose it must be remembered that loss of tissue manifests itself by cosmetic deficiencies, which may require a plastic *operation.* Hence great circumspection must be exercised

in removing tissue to promote healing of the wound. Particles that can be saved should be properly sutured and the wound given the attentions its character, size and location indicate. Foreign bodies should be removed, including clothing and detached bone spicula. Whatever is done, the patency of the nares and nasal cavities should be preserved, if possible, and adhesions and stenosis avoided by gauze or hollow metal or rubber splints introduced into the nares. If the nasal bones are depressed, it may be possible to elevate them. Infection is uncommon or not severe, hence a little more latitude can be extended in this regard when there is a possibility of conserving the contour of the nose and face by endeavoring to save tissue which under other circumstances would be removed.

Plastic Surgery of the Nose.—The numerous disfiguring wounds of the nose as well as the face have given to plastic surgery in this region an importance which it had never before realized. While the old principles governing this branch of surgical practice still obtain, they have been so greatly extended that what was formerly an uncommon procedure has become a matter of every-day experience. However, as this pertains to another branch of the service the details cannot be given in this manual. It will be sufficient to say that the results justify the care and study bestowed upon these afflicted victims of the war.

Comment.

Numerous cases of wounds of the external nose are reported by Castellani(1), Thost(4), Potter(2), W. F. Wilson(1), Alexander(7), Bowlby(1), Sieur and Rouvillois(1), Guyot(1), Denker(2) and others.

Ferreri(5) opposes replacement of fractured bones immediately on treating the wound, as this can easily be done with the finger or forceps when the swelling subsides. Morestin(1,

2, 3, 6, 10, 11, 15) has performed a multitude of nasal plastics. Delorme(2) and Ramsey, Grant, Whale and West(1) recommend peroxid of hydrogen for the primary treatment of the wound.

II. INJURIES OF THE NASAL CAVITIES.

The nasal cavities are subject to injuries from projectiles which penetrate through the external nose, the mouth, the cheek, the orbit or posteriorly through the neck and head. Those which have an anteroposterior direction are apt to lodge in the cervical vertebræ or base of the skull if they have sufficient propulsive force. Those passing obliquely may involve the sinuses, the orbit, the ear or neck, while those which have a transverse direction are least disposed to cause extensive or serious involvement of important structures.

The septum may be contused, dislocated, fractured, perforated or destroyed, or it may lodge the projectile or fragments of metal and other foreign substance.

The turbinates may be injured, fractured, misplaced or obliterated in whole or in part.

The floor of the nose may be perforated or penetrated by the projectile and the cribriform plate may be fractured or subjected to a loss of substance.

Treatment.—There are several important factors to be considered in connection with the treatment of wounds of the nasal cavities independent of complicating wounds:

1. Hemorrhage is a common accompaniment which requires treatment if the patient is seen early. If possible the bleeding-point should be found and stopped by pressure or by other means. The bleeding may originate in the pharynx from injury of a large vessel under which circumstances treatment applied to the nose can be of no service. When the flow of blood constitutes a serious drain on the patient and when it manifestly originates in the nasal cavities

the nose may be plugged from behind and from the front by any of the established methods. However, the plugs should not be allowed to remain long in that they promote infection. It is better to remove them and to repack rather than to permit them to remain long enough to result in an infection.

2. Primary Treatment of the Wound.—If the patient is seen sufficiently early all foreign bodies and lacerated particles and loose bones should be removed, the septum and turbinates replaced if possible and special care taken that denuded surfaces be not allowed to remain in contact. This is accomplished by judiciously removing any tags of tissue which may obstruct the lumen and by the use of hollow metal or rubber splints. Gauze may temporarily take the place of these splints or mica plates can be used.

If the septum is dislocated it should be replaced if possible, and if the septum is fractured the fragments should be placed in proper position and the nasal cavities tamponed with gauze strips covered by rubber tissue (like a cigarette drain), which will permit removal without pain or bleeding.

3. Foreign bodies, consisting of bullets, fragments of metal, clothing, bone, etc., should be removed at the first sitting unless they are too deeply embedded and the patient's condition does not warrant it. Later on if infection has resulted they should be removed. The methods are as follows:

(*a*) Through the anterior nares, usually without much difficulty, though it may be necessary to resect the septum or remove a portion of a turbinate. (*b*) By means of a radical maxillary operation, particularly if the foreign body is in the external wall of the nasal cavity. (*c*) By making an incision in the gingivolabial junction of the mucosa of the upper lip and the alveolus and raising the soft parts of the lip above the bony framework. (*d*) By one of the operations the basis of which is a temporary resection of the external nose.

4. *Infection is the rule,* particularly when there is a foreign body present.

5. Adhesion and stenosis are accidents which are difficult to avoid. They result from the dislocations, lacerations and fractures and from the juxtaposition of denuded surfaces. They menace the future health of the patient and constitute a marked inconvenience.

The prophylactic measures instituted in the primary treatment have already been detailed. When the septum is deflected with or without adhesions, submucous resection constitutes the remedy; a perforation as the result of operation is better than a badly deflected septum with adhesions.

The adhesions themselves should be cut away and gauze, rubber tissue or splint interposed between the cut surfaces. Unless a distinct gap is made between the two surfaces the adhesion will almost certainly reform. Adhesions in the vestibule almost always require a plastic operation.

Comment.

Milligan(3) employs the finger of a rubber glove packed with gauze as an effective splint for the prevention of adhesions. Ferreri(5) cautions against the use of posterior tamponade for hemorrhage. Whale(3) reports a case of fatal hemorrhage following wound by a shrapnel bullet which entered the free margin of the ala and cheek without exit wound. Autopsy showed that the bullet after passing through the nasal cavities and maxillary sinus had lodged in the bifurcation of the common carotid. Kafemann(1) states that when a bullet passes through the nose it usually crosses the anterior end of the middle turbinate or passes into the superior meatus, then through the septum and inferior or middle turbinate or the inferior or middle meatus on the other side and finally into the mouth or cheek, at the same time loosening several of the teeth or wounding the inferior maxillary. Moure(3) details a case in which a ball passed through the nasal cavity into the retropharyngeal regio

wounding the facial nerve in the stylomastoid foramen, and Castellani(2) another wound of the facial nerve from a bullet which entered through the nose. Brunetti(1) found one case out of 359 shrapnel injuries in which the projectile lodged in the nasal fossa. Ruttin(2) reports the case of a bullet which destroyed the right eye and was lodged in the left external nasal wall, half being in the antrum and half in the nasal cavity. Zimmermann(1) calls attention to the lack of proportion between the external wounds and the injury within the nasal cavities in these cases. Moriondo(2) found a piece of wood embedded in the middle meatus in a patient who had been struck on the nose by a hand grenade. Morestin(6) removed a shrapnel bullet which had been lodged in the septum, using a sublabial incision and elevating the paranasal tissues. Thomson(2) performed a submucous resection in a case of stenosis, divided the adhesions and introduced Lake's rubber splints. Gault(2) suggests the use of perforated bone plates to prevent the reformation of adhesions after they have been divided. Pegler(1) in a case in which the vestibule of the nose was closed by adhesions involving the turbinate, pared off the cartilage and sawed off the bony portion, by means of which a way was made to clear out the inferior turbinate in the usual manner and an India-rubber tube inserted in each nostril. In Hanszell's(1) case, electrolysis and careful submucous plastics were successful in complete atresia of the nose. O'Malley(4) relieved a case by submucous resection and another by punch forceps and McKenzie(3) one by diathermia. Stuart-Low(2) advises Moure's plastic. The ala having been freed and the soft parts toward the inner canthus turned up, passage is made through the cicatrized tissue and a long inner tracheotomy tube inserted. Threads introduced into the nose and nasopharynx and out of the mouth were moved seesaw fashion through the passageway that had been formed. Milligan(3) reports a case in which the cribriform plate was

so badly damaged that anosmia resulted and Hansemann(1) one in which perforation of the cribriform plate resulted from an explosion in the immediate neighborhood. W. F. Wilson(1) relates a case in which a piece of metal was found lying across the upper part of the nose at the level of the middle turbinate, causing suppuration. Canuyt(4) claims all foreign bodies in the nasal cavities, except when in the sphenoid or ethmoid, can be removed through the anterior nares. Bowlby(1) relates a case of a man who was shot across the face and through the nasal cavities from one zygoma to the other, and although the wound was below the level of the base of the skull, one frontal lobe and one temporosphenoidal lobe were reduced to a pulpy mass.

CHAPTER VIII.

INJURIES OF THE ACCESSORY SINUSES.

WOUNDS of the accessory sinuses, as a rule, are associated with wounds of the nasal cavity. However, maxillary sinus wounds are to be sought in connection with wounds of the malar and orbital regions and of the mouth, ethmoid with those of the orbit, sphenoid with those of the nasopharynx and cranial base and frontal with those of the vertex and glabella.

When the sinuses alone are involved the condition is not serious, at least there is nothing to be expected beyond an infection followed by suppuration. The sinus may be perforated or the fragment or ball may penetrate and lodge in the cavity or in its walls. Sometimes the foreign body, if it remains, causes no trouble whatever, but it has always a potential influence in the causation of a suppurative sinusitis and must be regarded as a danger. Not infrequently splinters and larger masses of bone may necrose and sequestrate, and if suppuration occurs the usual accompaniments of granulation and polypi may be expected. In addition to these the presence of a traumatic suppurative sinusitis always constitutes an invitation for general infection, meningitis and diseases of the lower respiratory tract. When the maxillary sinus wound communicates with the mouth, infection is more likely to take place and to prove annoying on account of the flow of pus into the mouth.

Emphysema may complicate the wound from air entering *the tissue and a pneumatocele* may form at the frontal sinus *and invade the cranial* cavity.

Treatment.—The wound treatment comprises whatever is required for the accompanying wounds and the removal of possible foreign bodies will be easy when the patient is seen immediately after the accident if the wound opening into the sinus is large enough. If they cannot be removed in this way, or if cicatrization has already taken place or if suppuration is already present, it is necessary to perform a radical operation. The intranasal operations are usually insufficient for these cases, as they do not afford an extensively wide view of the sinus. In France and England the Caldwell-Luc operation is advocated not only to relieve the suppurating sinusitis but also to extract an unoffending foreign body in order to obviate the occurrence of later suppuration. The Denker operation may likewise be employed, particularly if it is desired to obtain a somewhat larger view.

ETHMOID CELLS.

If a bullet has penetrated the ethmoid cells there is very little to be gained by withholding intranasal operative procedures, and hence the shattered bone and lacerated mucosa may be removed with the foreign body. When the foreign body lies near the cranial roof of the ethmoid cells, great care must be observed in manipulation for fear of injuring the intracranial structures and causing a meningitis.

FRONTAL SINUS.

In most instances when the frontal sinus is injured there is an external wound in connection with it. When seen early there is a possibility of recovery without infection if all particles of foreign matter are removed; but infection is nevertheless the rule in these cases. One of the usual external operations is performed in combination with an opening into the nose through which drainage is to be undertaken. The typical Killian may be performed, though it

not necessary to consider the possibilities of deformity, for if the external wound is at all extensive such an unpleasant result cannot be avoided. The operation under the usual circumstances is performed either through the wound opening or through an incision made which includes it. Intranasal operations are of no avail in these cases.

SPHENOID SINUS.

Foreign bodies in the sphenoid sinus walls are not common, as its situation signifies fatality unless the force of the ball is so spent that it can go no farther. While removal is likely to be a hazardous undertaking it can be done by opening the anterior wall of the sphenoid sinus after one of the usual methods.

Comment.

Ramsey, Grant, Whale and West(1) state that traumatic sinus suppuration injures the general health and may lead to laryngitis, septic pneumonia or bronchiectasis, and that erysipelas, cellulitis and middle-ear affections occur. Delorme(2) characterizes traumatism of the superior maxilla as follows: The borders may be crushed, its body perforated with bullets or subjected to comminuted fracture by shell fragments. It may be sometimes separated and dislodged from the facial skeleton or from its fellow. Injuries of the alveolar border may be complicated by fractures, dental traumatism and wounds from the propulsion of the teeth. Guyot(1) says that most wounds of the sinuses are followed by suppuration. O'Malley(1) reports the recovery of a patient in whom a bullet entered the vertex to the left of the middle line about one inch in front of the surface marking for the fissure of Rolando, apparently traversing the left half of the brain and finding exit from the skull by passing through the body of the sphenoid. Entering the nose by the roof of the left posterior nares it passed through the middle turbinate and

inferior meatal floor. Secondary hemorrhage in this case was checked by a postnasal gauze plug soaked in adrenalin and squeezed out. Ferreri(5) maintains that by early operative intervention in sinus wounds, suppurative meningo-encephalitis, thrombophlebitis, amaurosis, deafness and paralysis may be avoided. He states that much damage is done by the phosphorus which accompanies the shrapnel bullets. Seidel(1) advises wide opening of the sinus in wounds. Canuyt(4) states that perforation wounds of the maxiliary may not be infected, but if there is any displacement of bone, infection follows. He(5) also states that the radical maxillary sinus operation should be performed under local anesthesia by novocain injected through the foramen rotundum into the superior maxillary nerve. Guisez and Oudot(1) observed 48 cases of traumatism involving the sinuses, 34 maxillary, 8 fronto-ethmoidal, 1 bilateral frontal and 5 ethmoid. In the 34 cases of traumatic maxillary sinusitis the projectile passed directly into the superior maxillary or malar bone 18 times; in the frontal cases the penetration was always direct. Berruyer(1) finds that traumatic sinusitis has a greater tendency to resolve than the sinusitis met with in civil practice. His method is as follows: When there is a large communication between the maxillary sinus and the nose the facial wound is closed as soon as possible and the sinus disinfected through the nose. When the perforation is small and when the presence of a foreign body does not indicate a Caldwell-Luc operation a wide opening of the sinus into the nose suffices for a rapid cure. In a case of Beck(1) the radiograph indicated that the projectile was in the sphenoid, and it was undertaken to remove it after the method of a hypophysis operation with Killian's incision. The bullet was found, however, in the anterior portion of the ethmoid. Frühwald(1), in a frontal sinus fistula following a wound found a free sequestrum behind which was a thick membrane covered with granulations which did not pulsate

and which must have been the dura. Morestin(14) reports a similar case. La Grange(1) collected 609 cases of eye injuries which were complicated by wounds of the frontal sinus 31 times (5 per cent.) and the maxillary 110 (18.2 per cent.). Gloaguen(1) reports a fragment of shell remaining sixty-one days in the frontal sinus and a shrapnel bullet in the maxillary for one hundred and forty-eight days without causing the patient any disturbance. He cites three important facts in sinus wounds: (*a*) slight tendency of the infection to extend to adjacent structures; (*b*) exceptional tolerance for large foreign bodies; (*c*) rapid cure after operation. Kredel(1, 2) cites the case of a pneumatocele in the cranial cavity resulting from a frontal sinus wound and Duken(1) reports 2 others and Woderz(1) confirms Duken's view that the air passes through a fissure in the posterior sinus wall. Denker(1) advises wide opening of the sinuses in infection from wounds. Heindl(1) reports a case in which a foreign body was removed from the sphenoid and one in which a foreign body was removed from the ethmoid, and Morestin(5) one in which a shell fragment weighing 17 grams was removed from the sphenoid sinus after incision in the gingivolabial fold, raising the soft parts and resecting the septum.

CHAPTER IX.

INJURIES OF THE THROAT.

GENERAL CONSIDERATIONS.

WOUNDS of the throat affect the pharynx, larynx, trachea, esophagus or two or more of these organs. The pharynx is more frequently involved by projectiles which pass through the face, auditory organs and upper third of the neck. The larynx is injured in anterior and lateral wounds of the middle third of the neck and the trachea and esophagus in wounds in the lower third of the neck. The wound may be so extensive or the direction of the projectile such that these different organs become involved under other conditions than those mentioned. There are certain general considerations which concern wounds of the throat whether they involve the pharynx, larynx, trachea or esophagus.

1. **Wounds of the Muscles.**—The muscles usually affected are the sternomastoid, the trapezius, the other cervical muscles, including the extrinsic and intrinsic muscles of the larynx. Ordinarily such wounds have little effect on the muscle function, as the wounds heal readily. If, however, there has been a considerable loss of muscle substance there will be an equivalent scar formation with corresponding impaired function. It is sometimes necessary to stitch the muscle stumps together if this can be readily done, though in the majority of cases the cut ends will unite without such procedure. In this connection the predilection of the gas gangrene infection should not be overlooked. As a rule the infection travels longitudinally, while the muscle and adjoining muscles may be unaffected.

2. **Injury to Vessels.**—The great vascularity of the neck accounts for the severe and often fatal hemorrhages which accompany wounds of the neck, pharynx and larynx. Wounds of the external carotid, the superior thyroid, inferior maxillary, the internal carotid and the internal jugular vein are usually followed by death unless the hemorrhage is immediately checked. It often happens that a small projectile will push the vessel aside without injuring it. Furthermore, the instinctive lowering of the chin offers a considerable protection. The bleeding from a small vessel in the pharynx, larynx or trachea may be of serious moment, as the blood may suffocate the patient before he can be relieved. Dyspneic efforts and coughing due to the blood falling into the trachea will prolong the hemorrhage.

An arteriovenous aneurysm may result from a slight injury of a vessel, manifesting its presence a few days after the accident by vertigo and pressure symptoms. The obliteration of the lateral sinus has been advocated for serious hemorrhage of the cervical veins which is inaccessible or for which other methods cannot safely be undertaken.

3. **Injury to the Nerves.**—The nerves usually affected are the vagus, recurrent, spinal accessory, superior laryngeal and glossopharyngeal. The fibers of the recurrent may be injured in the vagus, spinal accessory or in the trunk of the nerve itself. Where there has been complete section the function is practically always permanently lost. This subject is considered at greater length under the heading of paralysis of the nerves of the throat.

4. **Endoscopy.**—The indirect method of examination of the throat is often inadequate, as the condition of the patient is apt to be such as to interdict its use. Furthermore, a pendant epiglottis does not interfere with endoscopic examination and conditions about the anterior commissure are *within endoscopic view.*

The trachea and esophagus can really not be properly

examined by any other method. The same method can be used with advantage for the removal of foreign bodies, cicatrices, webs, granulomata and for the incision of edematous tissue and abscess.

5. **Radiography.**—A foreign body and sometimes the site of fracture may be determined by radiography. Stereoscopic plates should be taken when possible, as the identification of the location is easier on account of the depth view that is gained. It is sometimes necessary to introduce a stomach-tube before taking the picture, when it is desired to differentiate between a tracheal and an esophageal foreign body. Often radioscopy is sufficient with other methods to locate the body.

6. **Subcutaneous Emphysema.**—This is a common concomitant which is favored when the wound is small and deep. It may be confined to the edges of the wound or it may extend over the neck and even to the thorax and face. It may be superficial or deep, causing very great swelling which may compromise respiration. Its continuous presence is a menace, as it favors infection. Unnecessary probing and forced respiratory efforts are likely to increase it.

7. **Dysphagia.**—Difficulty of swallowing may occur whether the respiratory or alimentary portions of the throat be concerned. While often severe enough when the larynx is involved its duration is longer and pain is greater when muscles of the pharynx, the palate or esophagus are affected.

8. **Treatment of the External Wounds.**—The customary rules are always to be observed, but it must be noted that while it is safe to cut away a considerable portion of the muscles and subcutaneous soft parts in order to obviate infection, the contour of the organs, the pharynx, esophagus, and larynx and trachea especially, must be respected. Stenosis and cicatricial contractions will result from any considerable loss of *substance* in these organs. Rest for the patient and *immobilization,* so far as possible, of the wounded parts

tracheotomy when necessary and interdiction of food by mouth (permitted under circumstances through a stomach-tube), for a longer or shorter period, are cardinal requirements by way of treatment.

The service of a laryngologist is necessary in order that a close watch may be kept on the progress of the case and on the development of complications.

9. **Complications.**—Among the common complications the following may be mentioned:

1. Secondary Hemorrhage.—A clot may become dislodged or an erosion into a vessel occur. These are usually serious and call for immediate action.

2. Infection.—Wounds of the throat are particularly liable to infection. This may show itself in the form of subcutaneous swelling or suppuration or abscess or phlegmon connected with the walls of the throat or the surrounding tissues. Retropharyngeal, peripharyngeal, peritracheal and mediastinal abscess and erysipelas should be anticipated.

3. Pneumonia.—Pneumonia is common not only in connection with the usual conditions which lead to its occurrence, but also on account of the aspiration of foreign particles, blood and pus, so common in injuries of the upper respiratory tract.

Comment.

Guisez(1) favors laryngoscopy by the use of a tube spatula for establishing a definite diagnosis in difficult cases and Jackson(1) feels that there is a large field of use for endoscopy in the present war. Sheen(1) chronicles the death of a patient, several months after being wounded in the neck by a shrapnel bullet, in whom autopsy revealed the presence of an aneurysmal sac the size of a tangerine orange connected with the common carotid by an opening a quarter of an inch from its origin from the aorta. Bond and Mitchell(1) ligated the facial and the jugular for an aneurysm of this type,

and Turner(1) operated on a case of arteriovenous aneurysm connected with the external carotid artery. Suchannek(1, 2), Rumpel(1), Heyrovsky(1), Castellani(3) and others report similar cases. Lannois and Patel(1 and 2) advise obliteration of the lateral sinus for carotid aneurysm situated high up and for arteriovenous communication. Their conclusions are: (*a*) obliteration of the lateral sinus is inoffensive from a physiologic and clinical point of view: (*b*) it permits the extraction of foreign bodies in the vascular zone at the base of the cranium; (*c*) in diffuse hemorrhage from lesions of the carotid at the base of the cranium it always safeguards venous hemorrhage; (*d*) in the treatment of arteriovenous communication of the internal carotid and internal jugular it constitutes, with the primary ligature of the carotid, the ligature of choice; (*e*) in severe wounds of the neck, with vascular lesions, it prevents and relieves rupture of the internal jugular, for which ligature may not be practicable by reason of the site of the wound and the friability of the vessel walls.

CHAPTER X.

INJURIES OF THE PHARYNX AND ESOPHAGUS.

I. INJURIES OF THE PHARYNX.

THE pharynx may be wounded by projectiles which penetrate into its walls or perforate through them. In the latter instance they are usually of small caliber, with rapid velocity, and they do little damage unless vessels or nerves are injured in their passages.

The projectile reaches the pharynx by way of the face, nasal cavities, accessory sinuses, orbit, neck or auditory apparatus and lodges in or passes through the pharynx wall into the structures beyond. For this reason there is usually more concern with reference to the injury done before or after the passage through the pharynx than in that done in pharynx itself.

The projectile may lodge in or pass through the cervical vertebræ posterior to the pharynx, the spinal canal, the pterygomaxillary fossa or base of the brain.

Besides the injury of the pharynx wall the palate, tonsils and tubal prominences may be injured or in part or wholly destroyed. The infection commonly manifests itself in and about the wound. Abscess in the pharyngeal walls and in the tissues around them occur with fair frequency, especially if there are any foreign bodies present.

Symptoms.—Injuries of the nasopharynx give few signs referable to the pharynx; the oropharynx and laryngopharynx are more notable in this regard.

The most common besides those already considered are:

1. *Hemorrhage.*—The chief danger exclusive of injury of *the large cervical* vessels is suffocation from blood falling into

the trachea and secondary hemorrhage which becomes serious before it is checked.

2. Pain.—Pain is at first due to the wound and then to the swelling incident to infection and inflammatory reaction. The pain is aggravated by swallowing and other actions of the pharyngeal muscles.

3. Expression of food or saliva from the cervical wound is a pathognomonic sign.

Treatment.—Little treatment is required beyond that for the external wound. If the wound is in the oropharynx or laryngopharynx no food should be swallowed for a time and the patient should be fed with a stomach-tube.

Projectiles should be removed, as they almost invariably lead to infection. This is not always easy particularly if they are lodged in the cervical vertebræ, the pterygomaxillary fossa or in the neighborhood of the great vessels. When abscesses form they should be incised.

Comment.

Faure(1) removed a ball from the posterior wall of the pharynx, between the mucosa and the constrictors, through an incision along the anterior border of the sternomastoid; dissection was made between the carotid and the jugular without wounding these vessels. Hope (1) cites the case in which a granulation on the postcricoid wall of the pharynx following a gunshot wound prevented deglutition. Removal completely relieved the patient. Beck(5) had a most interesting case in which a bullet lodged between the pharynx and cervical vertebræ, gradually descended until it reached the level of the third intercostal space. In this case a retropharyngeal abscess formed which was opened and a sequestrum of bone was removed from the retropharyngeal opening after which the patient recovered. Trömner(1) removed a bullet which had lodged behind the left tonsil. MacMahon(1

reëstablished a good voice in a patient who spoke like a cleft-palate sufferer, following a serious gunshot injury of the hard and soft palate. Castellani(3) removed a projectile from the suprahyoid region by an incision in the hyoid region. Morestin(7) removed a rifle ball from where it lodged between the tonsil and carotid. An incision was made limited to the upper pharynx beginning at the junction of the bony and soft palate, descending a little behind the anterior pillar and extending forward and below to the glossomaxillary furrow. According to Kafemann(1) the diagnosis of wounds of the pharynx is made by digital examination and pharyngoscopy. While the diagnosis of pharyngo-esophageal wounds is sometimes difficult, the appearance of alimentary matter or of saliva is pathognomonic, according to Delorme(2) and Guisez(2).

The pterygomaxillary fossa may sometimes lodge a projectile; Mauclaire(3) reports a case in which the ball was removed after resecting a small portion of the inferior maxilla and Toussaint(1) one of a similar character. According to Gosset(1), access to the pterygomaxillary fossa is opposed by two bony obstacles, the zygomatic arch of the temporal bone and coronoid process of the inferior maxillary. The removal of a projectile from this position is still further complicated by the great vascularity of the region and the presence of filaments of the facial nerve. He has operated four times, following the usual method of anatomic dissection, without any lesion of the facial and without using a single ligature to stop hemorrhage. An anteroposterior incision 4 or 5 cm. long is made over the zygomatic arch, the attachments of its superior border are laid free and then the zygomatic arch is cut before and behind with a Gigli saw or bone-cutting forceps so that it may be replaced after the operation. By the use of Farabeuf's retractors the coronoid process can be seen below the zygomatic arch and the masseter muscle and the muscular and tendinous fibers of the temporal muscle. A more or less extensive resection of the coronoid

is made or the operator may pass across the fibers of the temporal muscles or behind the posterior border of the coronoid. The foreign body may then be easily removed.

II. INJURIES OF THE ESOPHAGUS.

The esophagus is in a protected position, posterior to the larynx and trachea, and injuries of these organs is therefore a common accompaniment; and yet the esophagus is far more often wounded than might be supposed from these circumstances.

It may be contused or perforated or the projectile may lodge in the organ itself.

Wounds of the lower and middle portion are always complicated by wounds of the chest, which are usually fatal, either primarily or succeeding infection. When the esophagotracheal wall is involved, particles of food are likely to pass into the trachea and cause foreign-body pneumonia.

Symptoms and Diagnosis.—The symptoms of the esophagus wound are usually overshadowed by those of the accompanying wounds of the respiratory canal. Otherwise, the prominent symptoms are dysphagia and expression of food and saliva from the wound. The dysphagia will likely increase with the succeeding inflammation and infection or will replace the respiratory symptoms as the laryngotracheal wound improves.

Radioscopy will show the foreign body when it is present, though it may require stereoscopy or the introduction of a stomach-tube to determine whether it is in the esophagus, trachea or tissues surrounding them. Endoscopy is of the greatest importance in diagnosis as well as treatment.

Complications.—The main danger is infection, with resulting *periesophageal* or mediastinal abscess. Erosion or abscess *in the esophago*tracheal wall is usually fatal. Stricture

the esophagus will result if there is any considerable laceration of the walls.

Treatment.—The treatment is largely expectant. The patient must be kept quiet, food administered per rectum or through an esophageal tube when it can be introduced without danger. In the graver cases it may be necessary to perform gastrostomy. Foreign bodies are removed endoscopically when possible or by lateral pharyngotomy when necessary.

Comment.

Nuthall(1) observed only one case of esophagus wound in 8000 bullet wounds treated in a casualty clearing station in six months. On account of the close anatomic relationship to the air passages and carotid and jugular vessels it is probable that its injuries are overshadowed by the more serious effects of these structures. In the case reported by him a prevertebral abscess formed which ruptured into the pleural cavity and caused death. Guisez(1) had 6 cases of esophageal wounds and Madelung(1) had 7 which demonstrated that however serious the injuries there is a possibility of doing some good by early recognition and enlargement of the wounded portion of the esophagus. Berger(1) advises the complete aseptic closure of the wound if it is in the cervical portion and the complete interdiction of food and drink in order to avoid infection and to preserve the patient's life. Körner(4) considers that difficulty of swallowing which followed a contusion of the thorax from a shell explosion was due to a hematoma in the esophagus. Guisez(2) has found the larynx usually wounded at the same time as the esophagus. In one case in which tracheotomy was performed a phlegmon was observed at the esophageal opening due to a shell fragment enclosed under the esophageal mucosa. Cicatricial stenosis frequently follows esophageal traumatism. He advocates endoscopy(1) for determining the lesion in the

esophagus. Albrecht(1) reports a case in which, after a gunshot wound of the neck, an abscess of the hypopharynx and esophagus formed and ruptured. Later by means of endoscopy a piece of bone doubtless from the cervical vertebra was found at the opening of the esophagus and removed by forceps. In another case he opened, without result, a peri-esophageal abscess which followed injury from a shell fragment in the neighborhood. Later the esophagus was exposed as far down as the second tracheal ring and a large amount of pus was found. The patient died a short time after. H. Harris(1) cites a case in which a bullet passing between the larynx and esophagus caused a great deal of dyspnea for which tracheotomy was performed. An esophageal fistula which had formed soon closed. Frühwald(2) following a gunshot wound of the second tracheal ring found the opening of the esophagus surrounded by rough granulations.

CHAPTER XI.

INJURIES OF THE LARYNX AND TRACHEA.

I. INJURIES OF THE LARYNX.

WOUNDS of the larynx are of consequence from two important stand-points: the primary injury and the consequent stenosis which usually follows.

The projectile may be small and perforate the larynx or be lodged in its structure, or it may be large and very destructive to its component parts. The larynx may be contused, fractured or subject to laceration by the foreign body and portions of the cartilages may be dislocated.

The larynx is a very movable organ and hence, even though it be in the line of the projectile, it may be pushed aside and thus escape injury. Furthermore, as happens with the bloodvessels and nerves, it is usually protected by the chin, which is turned down to the sternum and even offers sufficient resistance if the projectile is of slight velocity.

There is often coincident injury of the cervical vessels or nerves whether the direction of the missile be anteroposterior or lateral.

Symptoms.—Among the more important symptoms are the following:

1. Hemorrhage is always a matter of serious concern whether it comes from injury of the larger vessels, or from a smaller vessel within the larynx. However, it is uncommon after the bleeding immediately incident to the injury. However, secondary hemorrhages do occur.

2. Dyspnea dominates the clinical picture of the condition and it is one of the most frequent symptoms. It may be occasioned by the foreign body itself, by the obstruction from the injured portions of the organ, by the blood or discharges

by the drawing in of the unsupported edges of the wound and by a paralysis of the laryngeal muscles.

3. Speech disturbances, usually aphonia, are due to the abnormality of the larynx, destruction of portions of the vocal cord, passage of air through the wound and paralysis of the laryngeal muscles.

4. Emphysema is frequent and often serious.

5. Dysphagia, usually manifest at first if the injury is severe, quite rapidly subsides unless the esophagus or pharynx be involved. Fluids and food may readily enter the larynx especially when the upper portions are injured.

6. Cough is often present but is usually aphonic.

Diagnosis.—This can be made from the passage of the air through the cervical wound, the emphysema, aphonia, dyspnea and the radiographic findings which can often be confirmed by laryngoscopy or endoscopy.

Complications.—In addition to the complications already enumerated, the following are to be considered:

1. Perichondritis arises from injury and infection of the cartilage. The chief danger is the formation of abscess and distortion of the laryngeal lumen from the necrosis of the cartilage.

2. Edema of the laryngeal mucosa is common and always to be feared. The injury and infection both contribute to its occurrence.

3. Stenosis, cicatrices and adhesions are extremely common results of the injury and often of the treatment. They will be considered in connection with similar conditions of the trachea.

4. Paralysis depends on the injury to the nerves. It constitutes a special study.

Treatment.—The future well-being of these patients depends on early treatment and its character and it therefore *behooves the surgeon* to exercise the greatest care compatible *with the conditions* in the management of these injuries.

1. External Wound.—The usual procedures are to be adopted, but as little of the component structure of the larynx should be removed as possible so as to reduce the liability of stenosis. Reliance may be placed on tincture of iodin and similar measures to prevent infection. Instrumental manipulation should be as restricted as possible.

2. Hemorrhage.—Digital compression is of service in checking the bleeding until it is possible to search for the bleeding vessel and ligate it. This applies to veins as well as arteries. If nothing else suffices, the carotid must be ligated.

3. Tracheotomy.—The asphyxia may be so urgent that a stab operation must be performed. In any event it may be performed in anticipation of edema and other obstructive condition. If there is sufficient time a carefully considered operation should be performed, using a tube sufficiently large for the purpose and selecting the portion of the laryngotracheal tube suitable for the particular case. Early tracheotomy reduces the danger of intralaryngeal or intratracheal hemorrhages very decidedly, not only by providing an exit for the blood but also by reducing the disposition to bleeding and by establishing proper oxygenation of the blood. Tracheotomy may be indicated later by such complications as edema, perichondritis and stenosis.

4. General Directions.—Rest and quietude are essential and the usual directions for wounds of the upper air passages, such as impregnation of the atmosphere of the room with moisture and such agents as compound tincture of benzoin, protective moist gauze covering, abstinence from food for a short time or feeding through a stomach-tube unless the upper portion of the larynx is free from injury.

5. Sutures.—Sutures are inadvisable unless the wound be very large, as they are very likely to break through by the efforts of coughing. Closing the superficial wound increases the disposition to emphysema.

6. Thyrotomy.—In extensive destruction it is better t open up the thyroid cartilage and expose the lesions to vie

7. Emphysema.—Emphysema is to be treated by scarification.

8. Foreign Bodies.—Foreign bodies should be removed. When they are small and movable they may often be removed by endoscopy but the larger ones, especially if they are buried, require a thyrotomy. Manipulations as to foreign bodies are best not undertaken unless a tracheotomy has already been performed.

9. Edema, Perichondritis and Abscess.—Incision through the natural passage is desirable where it can be effective, but in perichondrial abscesses it may be necessary, on account of its extent, to approach it by way of a thyrotomy.

10. Stenosis, Cicatrices and Adhesions.—In the treatment of laryngeal wounds and their complications these results should always be kept in mind and obviated so far as possible.

Comment.

Ramsey, Grant, Whale and West(1) state that the vagus and spinal accessory fibers are not likely to be injured without coincident damage to the jugular or carotid, while the recurrent laryngeal lies at a sufficient distance from these vessels to be injured independently of them. MacMahon(1) details a case in which a jagged piece of shell entered the tip of the right greater cornu of the hyoid and passed downward to the left through the larynx, lodging behind the left lobe of the thyroid. The larynx was tilted to the left, arytenoid region entirely replaced by scar tissue, glottis fixed, voice a hoarse whisper only. Speech was greatly improved by an appropriate plan of reëducation. Guisez(2) found 17 cases of laryngeal wounds out of a total of 726 coming under his observation. The thyroid cartilage, especially the pomum Adami, was injured in about a fourth of the cases; following this the *cricothyroid membranes* and the cricoid cartilage. According *to Delorme(2)*, wounds of the larynx and trachea may

diagnosticated by the expression of air through the cervical wound and by the rapid appearance of an extensive and deep emphysema. The presence of foreign bodies and of hematoma predispose to the development of a circumscribed or diffuse phlegmon. Scheier(1) saw 7 cases of larynx wounds in 2500 observed in four months. In 1 case he observed a piece of denuded thyroid cartilage discharged from a fistula in the neck six weeks after the injury. He includes in his report cases in which there were wounds of the cartilaginous plate; wounds of the thyroid with severe hemorrhage; shell fragment, causing marked thickening of the arytenoid, lodged between the fifth and sixth cervical vertebra, which he proposed to remove by lateral pharyngotomy; gunshot entering between the hyoid and thyroid and perforating the thyroid; fracture of the upper border of an ossified thyroid with ankylosis of the arytenoid. Thost(5) reports 11 cases of gunshot wound of the larynx, in 7 of which the larynx was either directly perforated or severely damaged by the projectile and in 4 indirectly affected through injury in the neighborhood. Lannois, Sargnon and d'Auriac(2) observed 57 cases of laryngeal and paralaryngeal traumatism, of which 25 were minimal lesions, 2 of foreign bodies, 8 of severe stenosis. Feuchtinger(1) does not think that tracheotomy is often indicated in injuries of the larynx. Kofler(1) reports a case in which more or less movable granulomata formed after gunshot wound of the larynx and W. Hill(1) one in which a tumor-like mass formed to the right of the anterior commissure, probably resulting from fracture of the thyroid cartilage. Colt(1) relates a case of death from edema of the glottis in connection with an injury of the face and thigh from shell splinters. Nadoleczny(3) states that the voice is usually restored after larynx injury, though the patient may be compelled to use a new method of vocalization. Muhlenkamp(1) had a case in which there was a division of the left vocal cords so that the patient appeared to have three vocal cords

Boehler(2) holds that tracheotomy is indicated in all cases of laryngeal or tracheal gunshot wounds in which severe dyspnea and emphysema occur. H. B. Jones(1) reports a case in which two months after a larynx wound no vocal cords could be found, only masses of granulation tissue in the region of the ventricular bands. Whale(2) relates a case in which a bullet traversed the larynx in the coronal plane, fracturing the greater cornu of the hyoid. Two days later he had an attack of profuse laryngeal hemorrhage which could not be checked. Autopsy showed that the right superior thyroid had been cleanly severed by the bullet. Two unusual cases are reported, 1 by Simmonds(1) of gunshot wound of the arytenoid exhibiting no laryngeal symptoms and 1 by Jones(1) of a soldier injured by a piece of shrapnel about the size of a finger-nail, which he coughed up three days later. Meisel(1) cites a case of shell fragment located under the left vocal cord removed by external laryngotomy, the indications being perichondritis and secondary edema. Dufourmentel(1) recommends that as little traumatism as possible be made in performing urgent tracheotomy and that breaks in the air canal be used for the purpose. According to Ferreri(4), laryngotracheal wounds with more or less loss of substance or of the cartilaginous substructure, with residual fistula and cicatricial stenosis, should be operated on only after a certain period of time, preferably when there is no fever. Bleyl(1) reports a case in which a shot remained two months in the larynx without symptoms except hoarseness and Körner(1) 1 in which a contusion of the larynx without wound was accompanied by a great interference with the arytenoid muscle due to fright. Malan(1) cites a number of cases of extensive emphysema in which asphyxia was imminent. Moriondo(1) was able to relieve a patient who had a fistula following a wound from a small caliber bullet by incising the fistula, removing a sequestrum of cartilage and granulation which had formed on the ventricular band. Davis(1) reports

case of almost complete laryngeal obstruction following a bayonet thrust into the larynx which destroyed the lower third of the thyroid. Boehler(1) recommends that an immediate tracheotomy be performed in all gunshot wounds of the larynx and trachea in which there are great difficulty of breathing and extensive emphysema, especially if the wounded man must be transported in a short time under unfavorable conditions. If the portal of entrance in the cartilage and mucous membrane is small, morphin and rest will bring about rapid improvement in breathing. Courtois-Suffit and Giroux(1) explain sudden death following removal of a Krishaber cannula, introduced on account of bullet wound in the larynx, on the basis of the phenomena of inhibition. Bleyl(2) reports a case in which a bullet some time after a wound by gunshot, which entered the right orbital cavity and injured the hard palate, was discovered at the anterior commissure. Lubinski(1) removed a projectile which had become impacted in the larynx. He recommends tracheotomy as a prophylactic measure, as edema of the glottis may be rapidly fatal. In Panzer's(1) case a tangential gunshot wound produced a gutter in the thyroid which resulted in severe edematous swelling and congestion of the interior of the larynx. Lannois, Sargnon and d'Auriac(1) give the following as the results of 76 wounds of the larynx: (*a*) laryngitis with infiltration more or less marked; (*b*) irritation, cicatrices and loss of substance; (*c*) foreign bodies; (*d*) larynx stenosis; (*e*) nervous aphonia; (*f*) laryngeal paralysis; (*g*) simple recurrent paralysis; (*h*) associated laryngeal paralysis. Grange(1) describes an operation for the removal of a shrapnel bullet lying between the ventricular band and the thyroid; an incision was made in the middle from the hyoid bone to the lower part of the thyroid isthmus; a tracheotomy was done and gauze packed into the trachea above the tracheotomy tube. The thyroid cartilage was fully exposed, with the cricothyroid below and the thyr

hyoid above. A transverse opening was made in the cricothyroid membrana and the thyroid cartilage divided in the middle line as far upward as the cushion of the epiglottis. An incision parallel and above the ventricular bands was made in the swelling which had been observed. This revealed the bullet, which was easily removed. Gerber(2) states that the infrequency of wounds of the larynx depends on its protected position, the elasticity of its cartilages and its movability. Coulet(1) reports a case of extreme swelling occupying the entire left half of the endolarynx, with dyspnea, aphonia, sialorrhea, displacement of the larynx to the left following a rifle ball passing through the neck, which yielded to hot compresses and inhalations although the recurrent paralysis persisted.

II. INJURIES OF THE TRACHEA.

Wounds of the trachea are likely to be more serious than those of the larynx, as the air passageway can less readily accommodate itself to the injury and relief measures are far less successful. Any considerable injury of the trachea is likely to be fatal, and loss of substance, except at the laryngeal end, does not yield to our present methods of surgical procedures. Still there are many cases that recover, particularly when there is only a slit-like injury or when there is only a slight loss of substance in the upper portions. Furthermore, injuries of the deeper portions are liable to be complicated by wounds of the aorta and other chest organs, which are followed immediately by death.

The trachea like the larynx is movable and for this reason may be pushed aside and only contused by the projectile, and it is further protected by the chin and sternum.

Symptoms.—The symptoms of tracheal injury correspond to those of the laryngeal injury except as to the location. The dyspnea is usually imminent, unless there is a sufficient

large external opening to permit respiration to take place. The lips of the wound are likely to be indrawn during inspiration and thus to constitute an obstruction to respiration. Emphysema is usual but dysphagia is not present unless the esophagus is also involved.

Diagnosis.—This is usually easy, the cardinal points being the location of the wound and the expression of air from the external wound at each expiration.

Complications.—These are practically the same as in laryngeal injuries.

Treatment.—If any good is to be done, treatment must be instituted early. The same plan is to be followed out as in laryngeal injuries, although it may be impossible to perform tracheotomy below the wound; in fact, it may be necessary to use the wound itself for the introduction of the tracheal tube. Foreign bodies may be removed and abscesses incised according to the best plan available.

Comment.

Guisez(1) was able to locate a bruise in the trachea from a fragment of shell which had entered the esophagotracheal wall. Chiari(1) advocates circular resection and suture of the trachea when portions of the trachea and larynx are completely lost through wounds. Care must be taken not to injure the recurrent laryngeal nerve. If the tracheal defect is so large that the lower stump cannot be moved sufficiently to permit the tracheal margin to be brought together the Gluck plastic operation must be performed. Gluck(1) has had good results from primary suture of tracheal wounds in transverse cuts across the trachea. Tracheotomy is indicated if hemorrhage is due to injury of the projecting tissue or cartilage and deep tracheotomy where there is much destruction of the soft parts or cartilage. Among the methods recommended for cases which cannot be relieved by simple

dilatation or which show a marked destruction of the organ which cannot be otherwise repaired are: (*a*) tracheotomy and laryngotomy with an artificial larynx scheme; (*b*) laryngostomy with dilatation; (*c*) horizontal resection of the trachea and larynx as far as the arytenoid region, laying the anterior wall of the esophagus bare, with conservation of the recurrent nerve; (*d*) closure of deep esophagotracheal fistula with skin plastic; (*e*) simple thyrotomy or total laryngofissure, with partial or complete exenteration of the epiglottis or resection of the cartilaginous framework, with total or partial laryngoplastic and formation of a permanent fissure; (*f*) total extirpation of the trachea and of the cricotracheal ligament to the bifurcation combined with skin plastic. Vallete(1) cites a case of extensive wound of the acromium and neck, with but slight injury to the trachea, followed by a rapidly increasing emphysema which very nearly suffocated the patient and which was promptly relieved by tracheotomy. W. Hill(2) opened a large intramural abscess of the trachea following a wound by a fragment of shell passing transversely through the neck.

from the skull, above the branching of the superior laryngeal. Onodi(1) reports paralysis of the glossopharyngeal, vagus and hypoglossal following gunshot wound of the face and neck and one of ankylosis of the cricoarytenoid articulation, with fixation of the vocal cord from a gunshot splinter in the cricoarytenoid region. Milligan(3) cites a case of injury of the fibers of the vagus which form the recurrent laryngeal in a bullet wound of the face in which the bullet was lodged in the second cervical vertebra. Trömner(2) had a case of bilateral recurrent paralysis due to gunshot injury, and Caldera(3) had a case of similar character. Ramonet(1) groups the nervous aphonia without disturbance of the apparent motility of the cords: (*a*) laryngeal neurosis; (*b*) simple recurrent paralysis; (*c*) associated laryngeal paralysis. Körner(5) writes of a case in which a shot entered the right cerebellar hemisphere from behind forward, causing simultaneous paralysis of the auditory, vagus and hypoglossal. He describes another case(3) in which a wound in the neck near the upper border of the cricord resulted in spinal accessory paralysis. Lannois, Sargnon and d'Auriac(1) observed 12 cases of traumatic laryngeal paralysis, 4 of abduction, 5 of adduction and 3 of slight paralysis; there were 3 of recurrent paralysis combined with paralysis of the brachial plexus and 3 of total paralysis of the four cranial nerves, *i. e.*, vagus, glossopharyngeal, spinal accessory and hypoglossal. According to Canuyt(1, 2) the recurrent may be irritated by the passage of a projectile in its neighborhood, manifesting itself in slight aphonia with a crow-like cough, or it may be badly injured or cut across, causing unilateral paralysis. There may be a recurrent paralysis from lesions of the vagus or vagospinal.

MacMillan(1) had a most interesting case in which the recurrent and hypoglossal were paralyzed. Mouiset and Arloing(1) one in which there were hypoglossal and glossopharyngeal lesions and Gross(1) one in which the foramen jugulare was involved, with symptoms of loss of taste in one-half of the tongue, atrophy of the genioglossal muscle and the ante

neck muscles. Ruttin(6) gives the history of a neck wound resulting in paralysis of the recurrent, sympathetic and hypoglossus and McKenzie(2) one of paralysis of the vagus; he asks the question, Should a vagus anastomosis be attempted? Maas(1) reports a case of bilateral hypoglossal paralysis. Gerstmann(1) one of combined facial and hypoglossal paralysis, and Leipen(1) one of paralysis of the spinal accessory and hypoglossal. Vernet(1) classifies the paralyses of these nerves as follows: ninth, paralysis of the superior constrictors of the pharynx (movement of the palate and of the posterior wall, disturbance in the swallowing of solids), disturbance of taste in the posterior portion of half the tongue; tenth, disturbance of sensation in half of the palate, pharynx and larynx, disturbance of salivation, cough crises, laryngeal troubles; eleventh, internal branch, paralysis of half the palate and larynx and acceleration of the pulse, external branch, paraylsis of the sternomastoid and trapezius; twelfth, hemiplegia of the tongue. Payr(1) advocates for irreparable total unilateral peripheral paralysis of the recurrent, with insufficient compensation, a V-shaped cartilage flap which has been excised from the thyroid cartilage at a point corresponding to the position of the vocal cord and which is then pressed deeply against the vocal muscle and the true vocal cord. By this means the vocal cord can be held in the median position. This cartilage prosthesis, which may be considered as unchangeable in its position and form, acts as a solid support for the paralyzed vocal cord and permits the hitherto missing closure of the glottis. Zange(3) recommends paraffin plastics of the cord in preference to the bloody procedure proposed by Payr. Trömner(1) reports a case of paralysis of the sympathetic to the eyes from a wound in the lateral triangle of the neck and Bass(1) one which caused distinct exophthalmos and contracted pupil. Ausch(1) had 2 cases in which the sympathetic was affected, both associated with hypoglossal paralysis, one with trigeminus and one with glossopharyngeal paralysis.

CHAPTER XIII.

STENOSIS OF THE LARYNX AND TRACHEA.

THE lumen of the laryngotracheal tube may be narrowed in various ways resulting from war injuries, of which the following have already been discussed:

1. Foreign bodies.
2. Acute processes due to inflammation or infections such as edema and abscess, within the walls or pressing on them.
3. Deformity from perichondritis, dislocation or necrosis of the cartilage.
4. Bilateral abductor paralysis.

In addition to these the following result from injuries or treatment of the condition:

1. Webs and adhesions formed by bridges of connective tissue stretching across portions of the lumen.
2. Cicatrices causing more or less narrowing and misplacement of the walls.
3. Tubular stenosis in which the lumen is partially or entirely occluded by a mass of cicatricial tissue which has formed in consequence of the severe traumatization of the laryngotracheal walls.

Symptoms.—While a tracheotomy tube is worn, there are no symptoms of respiratory obstruction; but when it is removed, inspiration through the larynx is found difficult or impossible. The same sign is manifested if the external opening of a fenestrated tracheal tube is closed. If there is no tracheotomy tube worn the symptoms of respiratory obstruction will come on gradually or there will be simply *interference with* voice production. Usually the laryngo-*tracheal tube* accommodates itself to a slowly increasing *stenosis until* the respiration efforts are insufficient to supp

the requisite air. An acute attack or the accumulation of discharge will intensify the dyspnea. Laryngoscopic or endoscopic examination aids or determines the diagnosis.

Treatment.—Various methods have been devised for the restoration of the lumen of the laryngotracheal tube and to retain its patulency. The type selected depends in a great measure on the condition present. The operation is called for occasionally to make it possible to remove the tracheal tube which of itself often induces stenosis.

1. Removing of webs and adhesions and obstructing tissue with the aid of the laryngoscope or of endoscopy. The minor forms of webs and adhesions are readily cut away with appropriate forceps introduced through the natural passageway. The operation is simple enough when performed by anyone who possesses the necessary technic. Dilatation may be combined with this method, in fact it is often necessary.

2. Thyrotomy. Cricothyrotomy.—The webs and adhesions may be severed and obstructing tissue removed through the agency of a thyrotomy or a cricothyrotomy. This is more serious than the previous plan but also more effective in appropriate cases. Dilatation is usually necessary afterward, particularly if there has been any considerable stenosis present.

3. Dilatation. Mackenzie's, Schoetter's or Levy's tubes or Thost's wedges are used and are successful in some cases.

4. Laryngostomy and cricotracheostomy are terms used to denote the operation by which an opening is made in the larynx or cricoid and trachea and employed for the purpose of dilatation of the stenosed tube, with the view of permitting it to close when the lumen is adequate. This method has given exceedingly good results and merits application whenever the stenosis cannot be relieved by simpler methods.

5. *Other methods* are more radical and include permanent *tracheotomy by attaching* the trachea to the skin opening *in complete stenosis* that cannot be relieved and extensive *plastic operations* on the larynx and trachea.

Comment.

Guisez(2) finds that cicatricial adhesions, bands and synechia occur as results of wounds of the interior of the larynx and that bands, valves and annular cicatrices definitely compromise the function of the trachea. By means of tracheoscopy(1) he was able to apply electrolysis and to determine when it was necessary to perform tracheotomy and when tracheolaryngostomy. He considers laryngostomy as the operation of last resort when grave inflammatory troubles are present and when the tracheotomy tube cannot be removed without endangering the life of the patient.

Kafemann(1) concludes that, apart from the danger to life, wounds of the larynx are serious on account of the consequent stenosis. Thost(2) uses the old Schroetter method of removal of the involved structures of the larynx, followed by dilatation. Lannois, Sargnon and d'Auriac(2) prefer retrograde dilatation for slight stenosis and laryngostomy for tight and secondary stenosis. Ramonet(1) groups the inflammatory and stenotic lesions into (*a*) laryngitis with infiltration more or less marked; (*b*) adhesions, cicatrices, loss of substance and fractures; (*c*) foreign bodies; and (*d*) laryngostenosis. Ferreri(4) before proceeding to a plastic operation introduces a rubber tube modelled for each individual and after a prolonged period of tolerance leaves the laryngotracheal covering exposed to the air and light for a certain period and only after he is convinced that the tube does not undergo any modification does he perform a plastic operation. He uses superimposed flaps, the skin of one of which is turned inward. Allenbach(1, 2) advocates dilatation with Schrotter's or O'Dwyer's tubes or Thost's wedges, and if these are unsuccessful, laryngofissure, with extirpation of the scar tissue when the framework of the larynx is preserved; when not, plastic operations are indicated, preferably according to the method *of Capella.* Lannois, Sargnon and d'Auriac(1) under the *group of adhesions,* cicatrices, loss of substance and fractures *saw 17 cases: 3* adhesions of the anterior portions of t

glottis, subglottic; 2 anterior subglottic cicatrices; 5 loss of substance and 7 fractures. There were 8 cases of stenosis only 2 of which required dilatation, the other 6 requiring laryngostomy. Moure(1) has devised a metallic appliance for maintaining the laryngotracheal opening sufficiently large for the purposes of laryngostomy. Garel(1) uses the McKenzie dilator graduated from 0 to 55. Sargnon(1) presents the following indications: (*a*) Tight cicatricial stenosis and bands which pass about the cricoid and reach the thyroid justify total laryngostomy, for, in such a case, tracheocricostomy will not be sufficiently high and will not give enough room and segmentary resection will require too large a tracheolaryngeal segment. (*b*) When the cicatrices or adhesions have been limited to the cricoid or near cricoid region, two methods may be used: tracheocricostomy which is preferable as it permits rapid dilatation and takes care of the respiratory and vocal function and, according to others, segmentary resection. (*c*) In agreement with Gluck and Hinsberg that partial subchondral resection of the diseased cartilage gives good results in perichondritis, the writer includes, however, a stomatous opening which alone will permit dilatation and attention to the stenosis after decanulation. (*d*) In severe stenosis in those who are canulated for incurable adduction of the cords, laryngostomy combined with resection of both arytenoids and curettage of the ventricles is an excellent method. Milligan(2) in order to prevent the readherence of the cords after division of the web introduces a little instrument which consists of a tracheotomy tube with the inner tube slit down to the greater part of its curve. A screw arrangement is introduced by the direct method through the holes in the tracheotomy tube so that its bulbous end lies in the tube itself. An assistant passes the inner tube through *the outer one,* thus fixing the perpendicular rod on which is a *triangular platform.* When it is judged that the cords lie *opposite the grooves of the* triangular platform a thread is *passed through the eyelet* and moored to the patient's ear.

CHAPTER XIV.

MISCELLANEOUS NOSE AND THROAT CONDITIONS.

I. GAS POISONING.

MANY varieties of gases are being used, some for their irritating effect, some for asphyxia and some in order to cause more or less lingering suffering and death.

The autopsies show very marked congestion of the mucosa of the upper respiratory tract, sometimes hemorrhages, fragmentation of the laryngeal muscles, a copious thin yellow frothy exudate. Swelling and ulceration and necrosis of the mucosa are frequently observed.

The best treatment is prophylactic, viz., the use of gas masks. These are very effective.

Comment.

Bradford and Elliot(1) found in an autopsy after gas poisoning (probably chlorin) the pharynx and trachea showing a purple plum-colored mucous membrane which was in marked contrast with the pinkish-white color of the unaffected portion of the esophagus. L. Hill(1) states that the mucosa of the trachea and larger bronchi exhibits intense congestion. The tubes are filled with a thin yellow frothy secretion, some of which escapes from the mouth and nose. Only the larger bronchi can be traced, the smaller being lost in a condition of intense congestion and edema which affects the entire lung. Crabb(1) notes similar findings. Bilancioni (1) sums up the lesions caused by asphyxiating gases as *follows: destruction* and rupture of the mucosa of the larynx, *trachea, large* bronchi and sometimes of the pulmonary

CHAPTER XII.

PARALYSIS IN CONNECTION WITH WOUNDS OF THE THROAT.

THE relation which the last four cranial nerves bear to the throat subjects them to paralysis in the presence of wounds involving the pharynx, larynx, trachea and esophagus. This paralysis may be transitory if there is merely a contusion of the nerve, but it is more commonly permanent from complete section. The four nerves concerned are:

1. The glossopharyngeal, supplying the superior constrictors, palatal muscles and taste in the posterior portion of the tongue.

2. The vagus, through the superior laryngeal, supplying sensation to the larynx and muscular action to the cricothyroideus and arytenoideus, sensation to the palate and pharynx; through the recurrent, supplying the other muscles of the larynx; and through the cardiac branches, producing the accelerator action to the heart.

3. The spinal accessory, carrying the fibers which pass through the vagus and constituting the superior laryngeal and cardioaccelerator activities and those which supply the muscles of the palate and the sternomastoid and trapezius.

4. The hypoglossal, supplying the tongue.

These may be affected individually or two or more together. The main trunks are fairly well protected, and are located in such an important region that wounds of the large vessels and other structures associated with nerve injury constitute *the greatest danger, in fact,* generally result in a fatal issue. *Still not a few cases have* been reported in which the nerve *trunks have been injured* with or without involvement of

important adjacent structures without being followed by death.

Recurrent Laryngeal Nerve.—So far as the larynx is concerned the recurrent laryngeal nerve is the most important, as it supplies most of the muscles of the larynx. Its fibers pass through the vagus and then the spinal accessory and paralysis of the muscles supervenes whenever these fibers are sectioned, whether in the vagus, spinal accessory or recurrent itself. If the paralysis is complete the cord will be in the cadaveric position, and, if incomplete, it will occupy the median position, and if there has been only an irritation from injury in the neighborhood there will be present slight aphonia and crow-like cough. These will disappear with the subsidence of the irritation or with the recovery from the contusion. If there has been section of the nerve fibers the paralysis will be permanent, but the voice will improve by reëducation or readjustment of the vocal mechanism.

Beyond the aphonia and cough there are no symptoms unless there be coincident paralysis of the recurrent or obstructive process on the other side. The diagnosis is made by laryngoscopic examination; hysterical and functional paralysis is usually bilateral and affects abduction with extreme rarity.

Superior Laryngeal.—Paralysis of this sensory nerve of the larynx renders the corresponding side of the larynx insensitive. When it is bilateral the larynx cannot appreciate the presence of foreign bodies and pneumonia supervenes; when unilateral the opposite side of the larynx is usually sufficient for the necessary normal reflex action.

Paralysis of Single Muscles.—Injury of the nerve supply of any laryngeal muscles results in corresponding paralysis.

Paralysis of the Vagus.—If the section is below the junction with the spinal accessory there will be paralysis of the *recurrent fibers*, paralysis of the palate and possible *interference with cardiac* acceleration. If above the junction, there *will be no* recurrent paralysis.

Paralysis of the Spinal Accessory.—If the internal branch is involved there will be corresponding paralysis of the larynx and palate and interference with cardiac acceleration; if the external branch is involved there will be paralysis of the trapezius and sternomastoid.

Paralysis of the Glossopharyngeal.—This shows itself in the loss of palate and superior constrictor muscular action and in the gustatory function of the corresponding posterior portion of the tongue.

Paralysis of the Hypoglossal.—Hemiplegia of the tongue is the characteristic symptom.

Paralysis of the Sympathetic.—The symptoms from injury of this nerve relate mainly to the eye: exophthalmos, contracted pupil, etc.

Treatment.—There is little to be done by way of treatment. The faradic current should be applied in the hope that there has only been an abrasion or an incomplete section. If the paralysis is complete and the cord is fixed, injection of paraffin will bring its edge nearer the midline for the purpose of voice production or one of the plastic operations may be performed. Reëducation is generally successful. In bilateral abductor paralysis, tracheotomy is necessary as a temporary procedure while intubation or removal of portions of the cord will give a more acceptable result. Nothing beyond faradization is usually done for the other types of paralysis.

Comment.

Guisez(2) thinks that faradization should be resorted to in all cases of laryngeal paralysis, although there is no hope of cure when the nerve has been sectioned. He reports(1) 4 cases of paralysis from section of the recurrent laryngeal and 2 of the superior laryngeal, and states that examination with a *spatula is the only* method for demonstrating these paralyses *and differentiating them* from arytenoid ankylosis. Körner(5) *details a case in which* a wound on the right side of the face *nd neck resulted in injury* of the vagus just after its exi

from the skull, above the branching of the superior laryngeal. Onodi(1) reports paralysis of the glossopharyngeal, vagus and hypoglossal following gunshot wound of the face and neck and one of ankylosis of the cricoarytenoid articulation, with fixation of the vocal cord from a gunshot splinter in the cricoarytenoid region. Milligan(3) cites a case of injury of the fibers of the vagus which form the recurrent laryngeal in a bullet wound of the face in which the bullet was lodged in the second cervical vertebra. Trömner(2) had a case of bilateral recurrent paralysis due to gunshot injury, and Caldera(3) had a case of similar character. Ramonet(1) groups the nervous aphonia without disturbance of the apparent motility of the cords: (*a*) laryngeal neurosis; (*b*) simple recurrent paralysis; (*c*) associated laryngeal paralysis. Körner(5) writes of a case in which a shot entered the right cerebellar hemisphere from behind forward, causing simultaneous paralysis of the auditory, vagus and hypoglossal. He describes another case(3) in which a wound in the neck near the upper border of the cricord resulted in spinal accessory paralysis. Lannois, Sargnon and d'Auriac(1) observed 12 cases of traumatic laryngeal paralysis, 4 of abduction, 5 of adduction and 3 of slight paralysis; there were 3 of recurrent paralysis combined with paralysis of the brachial plexus and 3 of total paralysis of the four cranial nerves, *i. e.*, vagus, glossopharyngeal, spinal accessory and hypoglossal. According to Canuyt(1, 2) the recurrent may be irritated by the passage of a projectile in its neighborhood, manifesting itself in slight aphonia with a crow-like cough, or it may be badly injured or cut across, causing unilateral paralysis. There may be a recurrent paralysis from lesions of the vagus or vagospinal.

MacMillan(1) had a most interesting case in which the recurrent and hypoglossal were paralyzed. Mouiset and Arloing(1) one in which there were hypoglossal and glossopharyngeal lesions and Gross(1) one in which the foramen jugulare was involved, with symptoms of loss of taste in one-half of the tongue, atrophy of the genioglossal muscle and the ante

neck muscles. Ruttin(6) gives the history of a neck wound resulting in paralysis of the recurrent, sympathetic and hypoglossus and McKenzie(2) one of paralysis of the vagus; he asks the question, Should a vagus anastomosis be attempted? Maas(1) reports a case of bilateral hypoglossal paralysis, Gerstmann(1) one of combined facial and hypoglossal paralysis, and Leipen(1) one of paralysis of the spinal accessory and hypoglossal. Vernet(1) classifies the paralyses of these nerves as follows: ninth, paralysis of the superior constrictors of the pharynx (movement of the palate and of the posterior wall, disturbance in the swallowing of solids), disturbance of taste in the posterior portion of half the tongue; tenth, disturbance of sensation in half of the palate, pharynx and larynx, disturbance of salivation, cough crises, laryngeal troubles; eleventh, internal branch, paralysis of half the palate and larynx and acceleration of the pulse, external branch, paraylsis of the sternomastoid and trapezius; twelfth, hemiplegia of the tongue. Payr(1) advocates for irreparable total unilateral peripheral paralysis of the recurrent, with insufficient compensation, a V-shaped cartilage flap which has been excised from the thyroid cartilage at a point corresponding to the position of the vocal cord and which is then pressed deeply against the vocal muscle and the true vocal cord. By this means the vocal cord can be held in the median position. This cartilage prosthesis, which may be considered as unchangeable in its position and form, acts as a solid support for the paralyzed vocal cord and permits the hitherto missing closure of the glottis. Zange(3) recommends paraffin plastics of the cord in preference to the bloody procedure proposed by Payr. Trömner(1) reports a case of paralysis of the sympathetic to the eyes from a wound in the lateral triangle of the neck and Bass(1) one which caused distinct exophthalmos and contracted pupil. Ausch(1) had 2 cases in which the sympathetic was affected, both associated with hypoglossal paralysis, one with trigeminus and one with glossopharyngeal paralysis.

CHAPTER XIII.

STENOSIS OF THE LARYNX AND TRACHEA.

THE lumen of the laryngotracheal tube may be narrowed in various ways resulting from war injuries, of which the following have already been discussed:

1. Foreign bodies.
2. Acute processes due to inflammation or infections such as edema and abscess, within the walls or pressing on them.
3. Deformity from perichondritis, dislocation or necrosis of the cartilage.
4. Bilateral abductor paralysis.

In addition to these the following result from injuries or treatment of the condition:

1. Webs and adhesions formed by bridges of connective tissue stretching across portions of the lumen.
2. Cicatrices causing more or less narrowing and misplacement of the walls.
3. Tubular stenosis in which the lumen is partially or entirely occluded by a mass of cicatricial tissue which has formed in consequence of the severe traumatization of the laryngotracheal walls.

Symptoms.—While a tracheotomy tube is worn, there are no symptoms of respiratory obstruction; but when it is removed, inspiration through the larynx is found difficult or impossible. The same sign is manifested if the external opening of a fenestrated tracheal tube is closed. If there is no tracheotomy tube worn the symptoms of respiratory obstruction will come on gradually or there will be simply *interference with* voice production. Usually the laryngo-*tracheal tube* accommodates itself to a slowly increasing *stenosis until the* respiration efforts are insufficient to supp

case of almost complete laryngeal obstruction following a bayonet thrust into the larynx which destroyed the lower third of the thyroid. Boehler(1) recommends that an immediate tracheotomy be performed in all gunshot wounds of the larynx and trachea in which there are great difficulty of breathing and extensive emphysema, especially if the wounded man must be transported in a short time under unfavorable conditions. If the portal of entrance in the cartilage and mucous membrane is small, morphin and rest will bring about rapid improvement in breathing. Courtois-Suffit and Giroux(1) explain sudden death following removal of a Krishaber cannula, introduced on account of bullet wound in the larynx, on the basis of the phenomena of inhibition. Bleyl(2) reports a case in which a bullet some time after a wound by gunshot, which entered the right orbital cavity and injured the hard palate, was discovered at the anterior commissure. Lubinski(1) removed a projectile which had become impacted in the larynx. He recommends tracheotomy as a prophylactic measure, as edema of the glottis may be rapidly fatal. In Panzer's(1) case a tangential gunshot wound produced a gutter in the thyroid which resulted in severe edematous swelling and congestion of the interior of the larynx. Lannois, Sargnon and d'Auriac(1) give the following as the results of 76 wounds of the larynx: (*a*) laryngitis with infiltration more or less marked; (*b*) irritation, cicatrices and loss of substance; (*c*) foreign bodies; (*d*) larynx stenosis; (*e*) nervous aphonia; (*f*) laryngeal paralysis; (*g*) simple recurrent paralysis; (*h*) associated laryngeal paralysis. Grange(1) describes an operation for the removal of a shrapnel bullet lying between the ventricular band and the thyroid; an incision was made in the middle from the hyoid bone to the lower part of the thyroid isthmus; a tracheotomy was done and gauze packed into the trachea above the tracheotomy tube. The thyroid cartilage was fully exposed, with the cricothyroid below and the thyr

hyoid above. A transverse opening was made in the cricothyroid membrana and the thyroid cartilage divided in the middle line as far upward as the cushion of the epiglottis. An incision parallel and above the ventricular bands was made in the swelling which had been observed. This revealed the bullet, which was easily removed. Gerber(2) states that the infrequency of wounds of the larynx depends on its protected position, the elasticity of its cartilages and its movability. Coulet(1) reports a case of extreme swelling occupying the entire left half of the endolarynx, with dyspnea, aphonia, sialorrhea, displacement of the larynx to the left following a rifle ball passing through the neck, which yielded to hot compresses and inhalations although the recurrent paralysis persisted.

II. INJURIES OF THE TRACHEA.

Wounds of the trachea are likely to be more serious than those of the larynx, as the air passageway can less readily accommodate itself to the injury and relief measures are far less successful. Any considerable injury of the trachea is likely to be fatal, and loss of substance, except at the laryngeal end, does not yield to our present methods of surgical procedures. Still there are many cases that recover, particularly when there is only a slit-like injury or when there is only a slight loss of substance in the upper portions. Furthermore, injuries of the deeper portions are liable to be complicated by wounds of the aorta and other chest organs, which are followed immediately by death.

The trachea like the larynx is movable and for this reason may be pushed aside and only contused by the projectile, and it is further protected by the chin and sternum.

Symptoms.—The symptoms of tracheal injury correspond to those of the laryngeal injury except as to the location. The dyspnea is usually imminent, unless there is a sufficient

of carriers in whom the bacteria are found in the nasopharynx, make it incumbent upon medical officers to pay close attention to the upper respiratory tract before and during an epidemic. The conditions of camp life which are conducive to the occurrence of inflammatory disease of the upper air tract, predispose to this and other types of infectious diseases.

Comment.

Ferreri(1) calls attention to the disposition of certain processes to become aggravated by army life, beyond what usually occurs. In another article(3) he expresses the conviction that camp life exposes the soldier to inflammatory processes either due to abnormal conformation of the nasal cavity or to a special predisposition of the adenoid tissue forming a fertile soil for germs of all kinds. Erysipelatous laryngitis and a type of acute pseudomembranous laryngitis are especially to be feared. Finder(2) discusses the relation of the tonsils to arthritis and nephritis which are common in soldiers. All those who have or have had rheumatism should be questioned as to the existence of acute tonsillitis, and the tonsil should be removed when they are affected. He also calls attention to the rapid outbreak of laryngeal tuberculosis under the influences present in war. Peters(1) has found two types of cerebrospinal meningitis: (*a*) those in which the sphenoid sinus is patent and (*b*) those in which one or both are closed. The former are usually mild, while the latter are more severe and fatal. Kenwood(1) is struck with the general coincidence of the prevalence of cerebrospinal meningitis and a high sick rate from catarrhal affections. This may be due to a common predisposing cause but it is probable that catarrhal conditions predispose to the disease, possibly exalt its virulence and also favor its spread. Liebault(1) describes a form of laryngitis which comes on in the trenches during a period of fatigue or in the course of the winter in

sectors in which soldiers were cold and wet and where they were required to stand in water for part of the time. By reason of bad hygiene they were affected with rheumatism, hoarseness with bronchitis and laryngitis. Some are evacuated very quickly, others remain for some time under treatment. The acute phenomena improve more or less. A slight laryngotracheal catarrh persists with cough, expectoration, hoarseness and aphonia and these with the fatigue, physical privations and loss of sleep occasioned by several months of trench life gives the impression of tuberculosis. Gordon(1) suggests the following for the disinfection of the nasopharynx of meningococcus carriers: (*a*) The air of the room when brought to the point of saturation by means of a steam spray containing 2 per cent. of chloramin acquires pronounced bactericidal properties for the staphylococcus epidermidis; (*b*) such air can be tolerated by human beings for a period varying from six to twenty minutes without discomfort and without harm; (*c*) the method succeeds temporarily in destroying the meningococcus in the nasopharynx of carriers. Wingrave(1) calls attention to the occurrence in soldiers of ulceration of the tonsils closely allied to, if not identical with, Vincent's angina, showing the following prominent features: (*a*) A deeply excavated and sloughing ulcer of one tonsil; (*b*) offensive fetid breath; (*c*) the presence of spirochetes and fusiform bodies in great numbers. Passler(1) asserts that there is an etiologic relation between streptomycosis of the mouth and the production of heart, nerve and joint disease and nephritis, especially in winter field work. He also states that nephritis is a result of tonsillitis under war conditions. Brodzki(1) confirms Passler's observations and includes "War Heart" as one of the results of microbic inundations of low virulence pyogenic streptococci which take place at each exacerbation of a chronic mouth infection. *In 610 cases of tonsillar* inflammation in a total clinical *material of 1200 patients*, articular rheumatism followed in *61 cases.*

CHAPTER XV.

MALINGERING.

ARMY service induces malingering for the purpose of evading military duty by reason of lack of courage or indisposition to leave home. The favorite methods are:

1. Self-inflicted wounds and burns.
2. Introduction of adventitious substances to simulate disease.
3. Simulation of sensory and motor disturbances.

I. SELF-INFLICTED WOUNDS AND BURNS.

It is remarkable to what extent men will go in inflicting wounds upon themselves and in the use of caustics for this purpose. A common plan is to introduce acids and other caustics into the auditory canal. This may be followed by a severe otitis media suppurativa, mastoid abscess and even meningitis and death.

Wounds are made with sharp instruments, pistol shots, scissors, etc., and the ear, larynx and pharynx are selected for the purpose.

II. INTRODUCTION OF ADVENTITIOUS SUBSTANCES TO SIMULATE DISEASE.

Cheese, clay and even human feces have been introduced into the external auditory canal for the purpose of simulating chronic suppurative otitis media. Powders, chalk and white of an egg have been used to simulate otorrhea.

III. SIMULATION OF SENSORY AND MOTOR DISTURBANCES.

Unilateral or bilateral deafness, deaf-mutism and aphonia are the usual manifestations of this type of simulation.

Simulation of Deafness and Speech Defects.—Simulation of deafness and speech defects is among the most prominent forms of malingering; in fact, it is so common either in the form of simulation proper or as exaggeration that many clinicians are disposed to consider it a pathologic entity. It is certain that many of the cases follow an extremely regular course and do not depend either on a desire or effort to deceive. Until further light is shed upon the differentiation of these cases, it is perhaps well to group them together.

Simulation of speech defects except when associated with deafness (deaf-mutism) is fairly uncommon, perhaps because exemption from service, except in a limited way, is not conferred by the condition simulated.

The methods of detection of simulation or exaggeration of deafness as well as of speech defects are very numerous indeed and depend on psychologic, medical and physical tests. They comprise the following:

1. **Observation.**—The patient is kept under the closest supervision, his various movements are observed and every effort made to determine by his actions whether he is able to speak or to hear more than he pretends. In any event, observation of this character, while it may not determine the simulation, frequently gives good grounds for suspicion.

2. **Psychologic Tests.**—The basis of these is to catch the patient unawares and by his answers to questions proposed when he is off his guard to demonstrate that he can hear or speak. For instance, during a physical examination he is asked to move his hand or stick out his tongue, or at the table he is asked to pass the bread. This method will

detect many of those who have not schooled themselves thoroughly in the task which they have set for themselves. If the newer psychologic tests are used by trained observers they will be far more effective then when employed by those with no special training in this particular.

3. **Reflexes.**—There are certain involuntary reflexes which depend on audition and whose presence constitutes a definite indication that complete deafness is at least absent.

(*a*) Dundas Grant's Test.—Dundas Grant has found that when a sudden sharp sound like a whistle is heard a short distance from the ear, the pupil will contract, then dilate, and when the noise ceases the pupil will contract and return to the normal state. The reflex is absent in complete labyrinthine deafness. In unilateral labyrinthine deafness it will be present only on the healthy side.

Sincard used a revolver for this purpose and Ostino a tuning-fork.

(*b*) Cochleopalpebral Reflex.—It has been found that a sudden noise will not only cause pupillary contraction, but also, varying with the intensity, a contraction of the orbicularis palpebrarum, the face muscles, the neck muscles and even the body muscles on the side stimulated. This is a very valuable aid in detecting simulation.

4. **Elevation of the Voice Caused by Use of a Deafening Appliance.**—Lombard's test is the most acceptable one of this type. If an individual with normal hearing is asked to read aloud before and during the application of a noise instrument in both ears it will be found that his voice will be elevated as soon as the deafener is applied. In complete bilateral labyrinthine deafness there will be no change in the voice; in unilateral labyrinthine deafness the change will not occur when the noise apparatus is applied to the affected ear but only when the unaffected ear is so treated. If the patient is simulating, the voice will be elevated unless the patient is familiar with this test and has practised to overcome the

disposition. An ordinary massage pump may be used for these tests instead of the noise apparatus.

5. **Disparity in Tuning-fork Tests.**—Unless the simulator is trained he is very apt to be confused by the tuning-fork test. Thus in unilateral labyrinthine deafness he will lateralize the vertex fork properly to his good ear, but the simulator who does not understand the test will very likely say that the sound of the tuning-fork disappears when the healthy ear is completely closed, although normally it is intensified.

Above all, the variability of his answers as to his perception of the tuning-fork tests is characteristic.

6. **Sensation Tests.**—If a clothes brush is passed over the back of a person with normal hearing and afterward the palm of the hand the individual will distinguish the one from the other. But if the two are done at the same time, the one on the right and the other on the left, the normal individual will not be able to differentiate the sense of touch and hearing whose impressions come at the same time, while the bilaterally deaf individual can analyze the tactile sensations and differentiate the brushing from the stroke of the hand.

7. **Obstruction Tests.**—These depend on obstructing the sound passageway without the knowledge of the person examined.

(*a*) By a Hollow Plug.—Into the good ear is fitted a plug with a hollow canal which the person examined is lead to believe is solid. If in a case of apparent unilateral deafness the patient says he cannot hear when this plug is inserted into his good ear he is a simulator.

(*b*) Binaural Tubes.—These tubes should be long enough to permit the examiner to speak into them without the subject being able to see him. To close one tube it is only necessary to compress it with the fingers or some form of forceps. The tests comprise the following:

1. Speaking into both tubes at the same time and compressing that leading to the unaffected ear.

2. Two persons with similar voices speaking one into each tube, using the same words. If on compressing that leading to the unaffected ear the patient continues to repeat the spoken words, he is a simulator.

3. Two persons speak into the tubes, one into each tube, using entirely different words, the subject being asked to repeat. If he can hear with both ears, he will soon become confused; if he is really deaf, he will repeat the words spoken in the tube leading to the good ear.

8. **Anesthetics.**—The subject is put under slight anesthesia, and upon being suddenly awakened if he is a simulator he will very likely be off his guard and will answer questions and thereby demonstrate that he is a simulator.

9. **Reëducation.**—The methods used in reëducation frequently furnish the means of detecting simulation. The vowel siren of Marage may be used to obtain the curve of hearing for the different vowels which Marage claims is characteristic of simulation.

Comment.

Caldera and Bolla(1) divide the tests for simulation of unilateral deafness into three groups: (*a*) those causing a modification of the voice when the noise apparatus is used; (*b*) those by virtue of which the subject is made to hear sounds with his alleged deaf ear which he thinks he hears with his healthy ear; (*c*) simultaneous conversations, through a tube provided for each ear. For simulation of bilateral deafness they employ tests dependent on surprise, as for instance, accosting a patient and asking a question without giving him time to reflect. Canuyt(3) thinks that the subjects should be watched and their attitude observed and much subterfuge employed in order to detect them. He considers *the noise* apparatus the only scientific plan. Molinié(3) *values the palpebral* reflex test very highly. When the sour

is of slight intensity there will be fairly constantly either a slight contraction of the orbicularis palpebrarum or a complete and rapid closure of the eyelids. This is sometimes accompanied by a slight contraction of the pupil. If a more constant sound with added force is employed several changes in myosis and mydriasis will be observed. If the sound is intensified there will be contraction of the frontal muscles and those ennervated by the facial. If the sound is very violent to the preceding phenomena will be added movements of the ocular globe, the head and neck and sometimes rotation of the body from the source of the sound. In the deaf these phenomena are lessened or partly lost. The psychic deafness can be eliminated and when the reflex is provoked by a sound which the subject denies he can hear, his good faith may be suspected. Lannois and Chavanne(5) maintain that simulation sometimes begins innocently in the course of concussion deafness; when the hearing improves the patient may overlook it or may wilfully deny it. Auerbach(1) states that the fundamental difference between malingerers and partially deaf persons consists in the fact that the latter always endeavor to hide their trouble while malingerers try to make their defect as evident as possible. Gault(3) holds that the cochleopalpebral reflex is totally negative in organic deafness from cerebrospinal meningitis, scarlatina, etc.; usually positive in most cases of total or subtotal deafness from cerebrospinal concussion; always positive but diminished in deafness or deaf-mutism from lesions of the middle or internal ear and normal in simulators. It may doubtless be retarded by volition, repetition of stimulus, fatigue and certain agents and favored by initial stimulus, rest, caffein, strychnin, etc. Maupetit(1) described Moure's modification of Lombard's noise apparatus and employs it in two classes of cases: (*a*) Those who say they cannot hear anything in either ear. In these the voice should not be changed in the slightest when the noise apparatus is applied.

If there is no change in the voice the subject may still be a simulator. He may be detected in the following way: A lesson in lip reading is given him and he is told that as soon as he becomes proficient in lip reading he may return home. Being anxious to leave the hospital he responds quickly to the proposed question, pretending to understand the movement of the lips. He is then tested with the noise apparatus, the examiner using the whisper. If he does not now understand the lip movements he is a simulator. (*b*) Those who complain of absolute unilateral deafness. In simulation the voice is elevated when the deafener is applied to the supposedly affected ear. Bilancioni(3) first employed ether but later substituted ethyl chloride, which he found more satisfactory, as only two or three inhalations were required. The brief anesthesia suffices to interrupt the state of voluntary inhibition which makes it possible for the subject to sustain the simulation. Berruyer(3) considers that the refusal of the subject to submit to etherization for test purposes is evidence of simulation. Nadoleczny's(2) plan consists in having two observers, one not visible to the subject. He is asked to read the lips of one observer. After first exercising with simple words he uses difficult words while the concealed observer speaks out these words so that the simulator may hear and repeat them. In a very extensive study of the subject, Moure and Pietri(2) detail the various tests of hearing and the methods of diagnosticating simulation of deafness, and hold with Sicard that there are two types of simulators: simulators of creation and simulators of fixation. They agree with his view that the former improvise and the latter repeat and hold with Pierre Marie that a distinction should be made between unconscious simulators and emotive neuropaths who are subject to suggestion and who acquire conditions *which do* not resemble organic lesions in any way *and exaggerators* who quickly become unconscious simulator *like the falsifier* who, convinced at first of the falsity of

assertion made to accomplish a purpose, ends by persuading himself of the authenticity of the statements by virtue of their repetition. Foy(1) explains the methods which he employs, some of which depend upon encouraging the subject to believe that he has acquired lip reading very rapidly and then proving by subterfuge that he hears and does not understand lip reading. He also uses a faradic apparatus (Gaiffe), composed of a coil receiving the current by induction from a fixed induction coil which is placed within it and from which it can be removed by sliding on a carriage 1 meter long. In the interior of the box two dry batteries give a steady current until they are used up. A vibrator provides vibrations of a constant value in two telephone receivers very equally balanced and connected with a secondary coil. A push-button, connected with the apparatus by a long conducting wire, makes it possible to interrupt and to reëstablish the current at a distance.

CHAPTER XVI.

THE EAR AND AVIATION.[1]

In aviation we have a practical example of the importance of the ear in maintaining equilibrium. It is now recognized that equilibrium is made possible by three senses—the balance sense of the internal ear, sight, and a group of general impressions which for convenience is called the "muscle sense." It is not necessary for an individual to have perfect internal ears, perfect sight and perfect muscle sense in order to have good equilibrium. If the internal ears are impaired the individual can maintain his equilibrium by means of sight and the muscle sense; if his sight is impaired, the ear sense and the muscle sense enable him to maintain his balance; and if his muscle sense is impaired, as in tabes, his ear sense and sight are sufficient to enable him to stand and walk with confidence and accuracy. For this reason we must remember that, through various toxemias, such as mumps, syphilis and the infectious fevers, a person may have an impairment and even a complete destruction of his ear balance sense and yet not be in any way conscious of this defect, simply because his sight and muscle sense make it possible for him to maintain his equilibrium.

These facts, however, take for granted that the individual is on "terra firma." When the human being becomes a bird, as it were, he suddenly finds himself in an entirely new

[1] *This chapter* is a reprint of a paper published by Major Isaac H. *Jones in the* Journal of the American Medical Association, vol. lxix *1607.*

environment. Without functionating internal ears it is impossible for a person to be a good bird-man. When flying through the air, on what does the aviator rely in order to maintain his equilibrium and that of the aëroplane? Can he rely on sight? Hardly; for when he is sailing through the clouds or darkness, his eyes cannot give him the slightest information about his position in space—not even whether he is right side up or upside down. As regards the muscle sense, it is undoubtedly true that it plays a certain part; but when the aviator is seated on an unstable and rapidly moving machine, it is hardly conceivable that the weight of his body could determine and maintain his position in space merely by the sensing of gravity. In order, therefore, to preserve that wonderful accuracy necessary in controlling such a delicate mechanism as the flying machine, he relies pre-eminently on his ear balance sense. It is easily conceivable that some of the unexplained accidents in aviating may be due to a concussion of the internal ear produced either by the deafening roar of the engine or by the decrease of the air-pressure when at great heights. Also in a rapid ascent from a denser to a rarer air there occurs an oxygen insufficiency which has a direct effect on the ear mechanism through the blood stream. It is also highly probable that many an aviator has gone to his death because, all unknown to him, he did not possess a normal ear mechanism; in the presence of a combination of difficulties in which all normal faculties would be requisite, because of an imperfect ear mechanism he was unable to maintain his balance.

To realize the importance of the ear in the matter of flying, it is only necessary to consider a bird flying in a cloud. His muscle sense naturally means practically nothing to him; his sight is of no help. He relies almost exclusively, therefore, *on normally functionating* semicircular canals, which, as we *know, are wonderfully* developed in the bird.

Summarizing, therefore, even when an individual is stand-

ing or walking on the earth, his ears constitute his sense organs of balance; as long as he remains on the earth he has in addition the contributory help of information received from his muscle sense and his sight. When he rises above the earth and flies in the dark it is obvious that these contributory factors are practically eliminated and that he must rely almost exclusively on the ear balance sense.

Since normal internal ears are such an asset—in fact a prime requisite—for the aviator, common prudence would suggest a most careful examination of the degree of function of one's internal ears before taking up flying as an occupation. The ear tests furnish exact and mathematical data concerning the function not only of the internal ear, but also of the entire vestibular apparatus; this includes the ears themselves, the eighth nerve, the brain stem, the cerebellum and the entire balance mechanism.

When it was announced that a state of war existed between the United States and Germany, it at once became apparent that a tremendous number of aviators must be secured for the military service within the shortest possible time. The medical problem consisted of selecting thousands of physically equipped candidates for aviation and placing them in training for war service immediately. The Medical Department found it necessary to decide on new methods of physical examination and to adopt new standards of physical qualifications for this branch of the service. This had to be done not merely for one place or for one examining group; it was necessary to make the tests practicable for cities in all parts of the United States, without, at the same time, in any way lowering the requisite rigid standards or lessening the completeness of the examination. How could this be done? In a word, such an ideal could be attained only by: (1) the standardization of the tests, and (2) the standardization of *the examiners.*

STANDARDIZATION OF TESTS.

The methods presented in this paper were adopted in May, 1917, as the standard for the United States Army. The following briefly summarizes the fundamental principles underlying the examination for aviators. The aviator must be in a sense the "superman." He must have 20/20 vision without glasses. He must have 40/40 hearing. Such requirements are higher than for most branches of military service. A candidate for every branch of service must conform to a certain physical standard; he must be a normal man, such as would satisfy the average life insurance company, with the additional requirements of a certain relative height, weight and chest measurement, and a definite visual and auditory acuity. Like any other candidate for service, the aviator must conform to all these requirements and in addition must possess visual and auditory acuity to a high degree. There is, however, an attribute not required by any other branch of the military service that is indispensable to the perfect aviator —a good balance mechanism. Therefore the peculiar test, applied to the aviator alone, is the special examination of the equilibratory portion of the internal ear.

As presented in the official blank, the equilibrium and the vestibular tests are made thus:

The nystagmus, past pointing and falling after turning are tested. The turning chair must have a head rest which will hold the head 30 degrees forward, a foot rest and a stop pedal. (The American Modification of the Bárány chair is officially required. This made possible the establishment of an absolute standard. While the tests could be made by using other types of turning chairs, an exact quantitative estimation of the responses can be definitely established only by the use of a standardized chair.)

(a) **Nystagmus.**—First of all, a spontaneous nystagmus must be looked for. It is noted whether there is any twitching

of the eyes when gazing straight ahead, or looking either to the extreme right, the extreme left, up or down. With the head forward 30 degrees, the candidate is turned to the right, eyes closed, ten turns in twenty seconds. The instant the chair is stopped, the stop watch is clicked; the candidate opens his eyes and looks straight ahead at some distant point. There should occur a horizontal nystagmus to the left of twenty-six seconds' duration. The candidate then closes his eyes and is turned to the left; there should occur a horizontal nystagmus to the right, of twenty-six seconds' duration. A variation of ten seconds is allowable (either as low as sixteen seconds or as high as thirty-six seconds).

(*b*) **Pointing.**—1. The candidate closes his eyes, sitting in a chair facing the examiner, touches the examiner's finger held in front of him, raises his arm to the perpendicular position, lowers the arm, and attempts to find the examiner's finger. This is done first with the right and then with the left arm. The normal person is always able to find the finger.

2. The pointing test is repeated after turning to the right, ten turns in ten seconds. During the last turn, the stop pedal is released, and as the chair comes into position, it becomes locked. The right arm is tested, then the left, then the right, then the left, until candidate ceases to past point. The absolutely normal will past point to the right three times with each arm, if needless delay is avoided. (However, one past pointing to the right of each arm qualifies, if the nystagmus and falling are normal.)

3. The past pointing is repeated after turning to the left. (Similarly, one past pointing of each arm to the left qualifies, if the nystagmus and falling are normal.)

(*c*) **Falling.**—The candidate's head is inclined 90 degrees forward. He is turned to the right, five turns in ten seconds. On stopping, the candidate quietly sits up, eyes closed, and *should fall to the* right. This tests the vertical semicircular *canals. He is* turned to the left, the head forward 90 degrees *on stopping,* he again sits up, and should fall to the left.

Obviously these tests as presented in this blank are not intended to make a diagnosis of a pathologic lesion. The object is merely to determine whether or not the ear mechanism is normal. If, in these tests, the canditate shows normal responses in nystagmus, past pointing and falling, he is fit for the Aviation Service; if he does not, he is unfit for that service.

These simple turning tests eliminate all unnecessary time consuming diagnostic procedures. The entire series of tests as outlined in the blank requires only three and three-fourths minutes, and yet in this short time we are able to determine the integrity of the internal ears, the eighth nerves, and the pathways through the medulla oblongata, the pons, the six cerebellar peduncles, the cerebellum itself and the cerebral crura to the cerebral cortex.

Incidentally, these tests are in no sense severe, and are in fact seldom regarded even as unpleasant. Occasionally nausea occurs after a few turnings; it is then merely necessary to stop the examination for the time being and to complete the remainder of the tests after an interval of a half-hour. There is no need whatever to make these tests in any way distressing to the candidate.

These turning tests quickly separate the obviously fit from the unfit. The majority of the candidates show normal responses; no further testing is required, and they therefore qualify and are accepted. Some candidates show such markedly subnormal responses that they are immediately disqualified and rejected. A limited number give what might be termed "border-line" responses; the question then arises, Has this particular applicant sufficient balance sense to become an aviator? It is here that the caloric test is useful. The turning has tested both the right and the left ears *simultaneously*. The caloric method enables us to test each ear *separately*. Water at 68° F. is allowed to run into the external *auditory canal* from a height of about 3 feet through a stop-

nozzle, with the head tilted 30 degrees forward, until the eyes are seen to jerk or the individual becomes dizzy. The length of time from the beginning of the douching until the jerking of the eyes becomes apparent, or until the applicant says he is dizzy, is accurately measured by a stop watch. The type of nystagmus is then noted. It should be rotary, and the direction of the jerk should be to the side opposite to the ear douched. The length of time shown by the stop watch in the normal is forty seconds. The eyes are then closed and the past pointing is taken. The head is then immediately inclined backward 60 degrees from the perpendicular (or 90 degrees from the original position). There should then appear a horizontal nystagmus to the side opposite to the ear douched. The eyes are then closed, and the past pointing is taken with the head in this position. The left ear is then douched, and the same procedure carried out. If the caloric test applied in one of these "border-line" cases shows only a slight impairment of the responses from each ear, the candidate is qualified. A slight impairment would be indicated if instead of the normal forty seconds of douching, there was required not more than ninety seconds of douching. If one ear shows normal responses, whereas the other ear shows responses only after more than ninety seconds of douching, the candidate is disqualified. Care should be taken to be certain that the cold water is reaching the drum-head during the caloric test, as wax or other obstruction in the external canal would interfere with the responses in a perfectly normal individual.

The examination of a candidate for the aviation service is a different matter from the examination of a patient. We are dealing with an alert mind, anxious to make the best showing possible. Many candidates feel that "jumping eyes" and evidences of vertigo are signs of weakness and would be counted against them. Because of this anxiety, many candidates attempt to shorten the duration of the nystagmus

by fixing the eyes on some near object. It is perfectly possible by the fixing of the eyes to shorten the duration of the nystagmus. It is a common experience in this work to note that when many observers are standing about the candidate and in his line of vision, the nystagmus is usually of short duration. If these observers are asked to stand back out of the line of vision, the same candidate almost invariably shows a longer duration of nystagmus. Further to obviate fixation of the eyes, it is always necessary to place the chair near a large window so that the candidate has an unobstructed view of an object placed at "infinity"—over 100 feet. Furthermore, instead of obeying the natural impulse to past point, candidates frequently make a mental calculation as to the vertigo induced, and voluntarily attempt not to past point. This is also true of falling. In such instances, the examiner, bearing in mind the type of individual with whom he is dealing, urges the applicant to "act perfectly naturally," and is then usually able to elicit a true response to the test. Supposing, however, that the candidate still fails to past point, although he has shown a normal nystagmus and falling, we are able to decide the matter finally in the following way: First the quantitative estimation of vertigo is taken. The after-turning vertigo is measured as follows: The candidate is turned to the right, ten turns in ten seconds with the eyes closed. As he is being turned he is asked to describe his sensations and to keep on telling in which direction he feels he is being turned; thus he will say, "To the right, to the right, to the right," etc., until the chair is stopped; then he will feel himself turning in the opposite direction and will say, "Now I am going to the left, to the left, to the left," etc., when as a matter of fact he is sitting perfectly still in the chair. The duration of this sensation of vertigo from the *time that the chair is stopped* until he ceases to feel that he *is going to the left is taken* in seconds with the stop watch. *The normal should show* an after-turning vertigo of twenty-

six seconds. The test is then repeated by turning to the left, and the candidate should exhibit a vertigo in the opposite direction of twenty-six seconds. Should the candidate show over sixteen seconds of vertigo in both directions, having previously shown a normal nystagmus and falling, the examiner then realizes that the absence of past pointing was probably due to a calculated correction rather than to any pathologic condition. The question is definitely determined by douching the ears. Although a candidate can estimate the significance of the sensation of vertigo after turning, he has no control over this sensation after douching; he is unable to calculate the meaning of the vertigo produced by the caloric test. Therefore, if he fails to past point after the douching tests, he is definitely disqualified.

STANDARDIZATION OF EXAMINERS.

So much for the standardization of the tests themselves. Equally important was the problem of the standardization of the examiners. For this purpose a medical officer was sent under special orders to each of thirty cities throughout the United States, and in each one of these cities there was established a medical unit for the examination of candidates for the Aviation Service. The requirements of the tests were fully explained to each medical unit, so that not only the same equipment is used, but also exactly the same technic. This rendered it impossible for any candidate to say, "I wish I had been examined in a certain city where the tests are easy, rather than in a certain other city where the tests are exacting." Those otologists were selected who were most expert in the Bárány tests, and given intensive training by the medical officer sent for the purpose of establishing a uniform technic. Thus, in a few months the testing was put on an absolutely uniform basis in all examining centers.

In order to save time, already existing institutions, such a

large hospitals or State universities with their equipments, were utilized as these examining centers. Volunteer staffs of civilian consultants were locally organized, and the work of the examining centers systematized to a point of highest efficiency, with the result that within a few days of the arrival of the medical officer at the examining center the work was in full swing. By this method of decentralization, the examination of thousands of applicants in a minimum space of time was made possible. First of all it was necessary to make sure that those in charge of each examining center were fully equipped and capable to make these tests; this once assured, full authority and responsibility were vested in the medical officer in charge of each center. Thirty medical aviation centers, each examining from ten to forty candidates a day, provided immediately the thousands of men required.

It is obvious to the candidate himself, that if he is deficient in his ear balance sense he is not only a danger to the service but he is also unnecessarily imperilling his own life when he attempts to fly. Certain members of the medical profession and certain veteran fliers, because of the newness of these methods, expressed skepticism in regard to their value. One physician, a member of an examining unit, was surprised to find that when he himself was examined, he showed an almost complete lack of ear balance sense. The turning and caloric tests failed to produce nystagmus, vertigo, past pointing and falling. This impairment of the ear mechanism was directly traceable to a severe attack of mumps in childhood, during which he had suffered from both of the usual complications of mumps—an orchitis and an involvement of the internal ears. His skepticism was changed to enthusiastic conviction when he thus was made to realize that without the Bárány tests he would have had no conception of this physical disability, the only suggestion of which, up to that time, had been his knowledge that he did not become seasick.

All experienced aviators that have been examined have,

without exception, shown normal responses in the turning chair. Those veteran aviators whose attention has been called to these methods of testing have expressed their conviction of the practicability of the safeguards provided by these tests in determining whether or not a man has what they speak of as "air sense." One seasoned American flier of fifteen years' experience stated that his doubt changed to conviction after he was examined in the turning chair; he volunteered a statement that from his intimate knowledge of the circumstances attending the death of at least three aviators, who were killed while flying, their failure to negotiate difficulties of no unusual degree which resulted in their death might now be understood as an expression of their lack of this sense. He further added that in his judgment, if these tests had been available in the early days of flying, many a life might have been spared.

The value of the past-pointing test is well illustrated by one candidate who proved to have a post-traumatic cerebellar lesion, which was first detected by the isolated absence of past pointing of the left arm to the right. Neurologic examination then demonstrated classical signs of lesion of the left cerebellar hemisphere. Here was a man with distinctly impaired cerebellar function attempting to enter a service in which the utmost demands are made on the cerebellum.

One ardent applicant was disqualified because of a markedly impaired internal ear, in both the cochlear and vestibular portions. It has since been learned that he went to another country, where he was accepted in the aviation service as a flier. Obviously the requirement in that country is not so high as in the United States. At the present time in the United States a high standard is required because this country is in a position to pick and choose. The vast numbers of splendid applicants makes this possible. For this reason *these hand-picked* men will constitute not only the largest but *also the most* capable and finest aviation service in the world

CHAPTER XVII.

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